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THE ROYAL AERONAUTICAL SOCIETY

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REVIEWS

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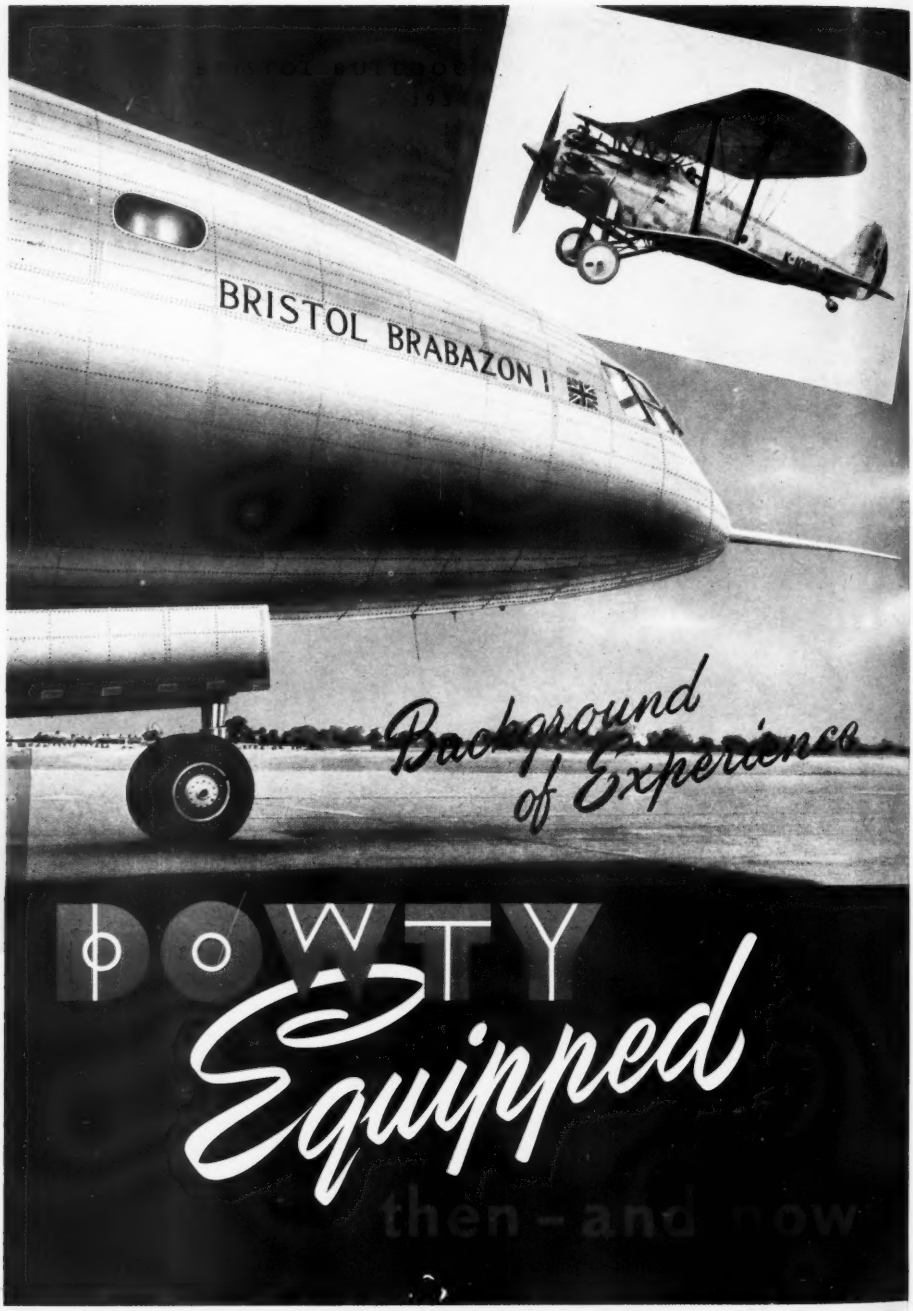

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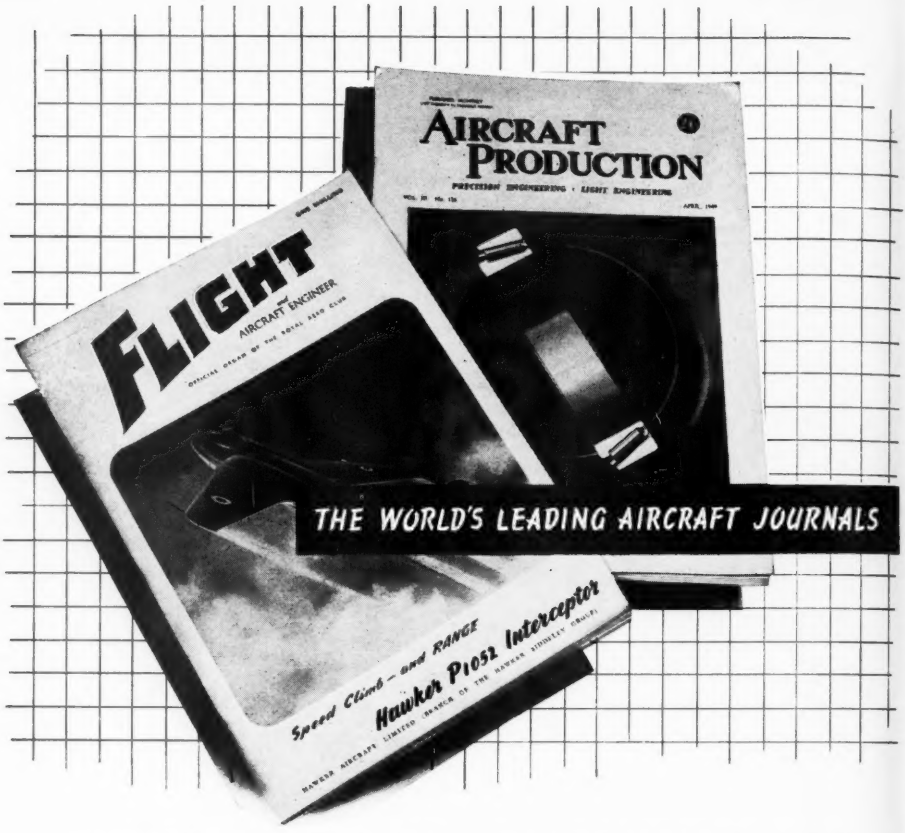

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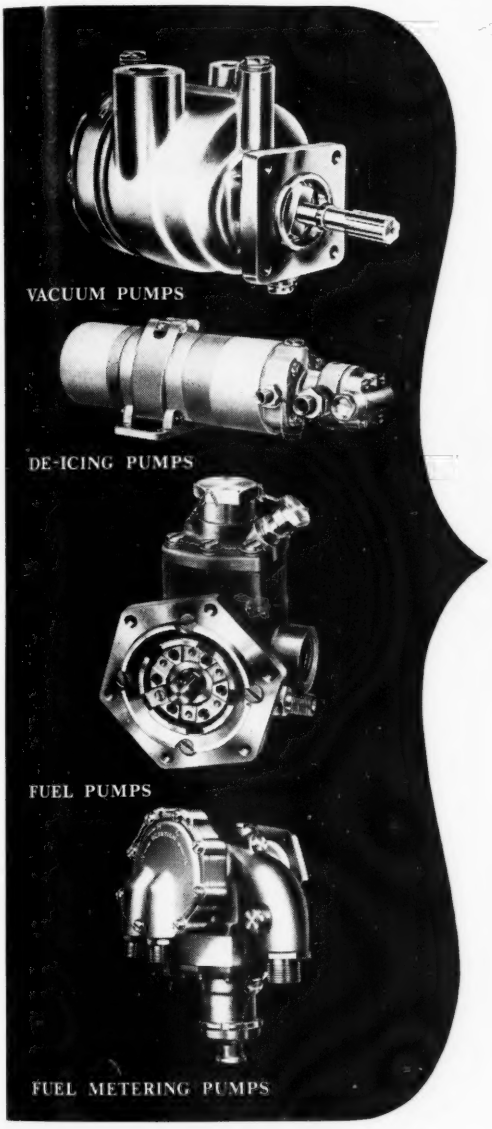

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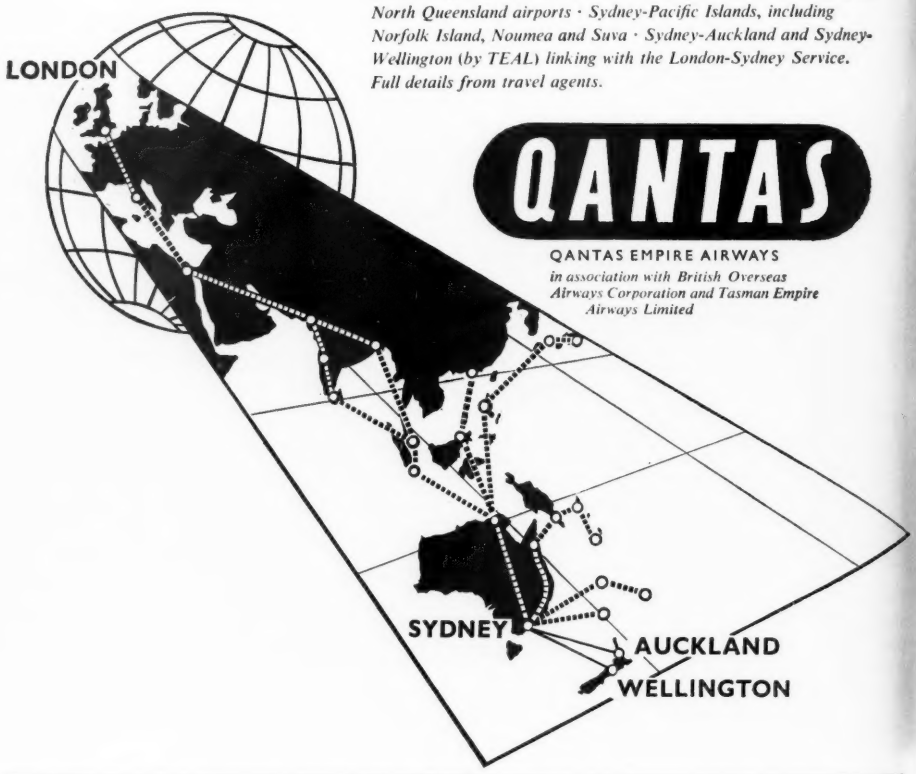

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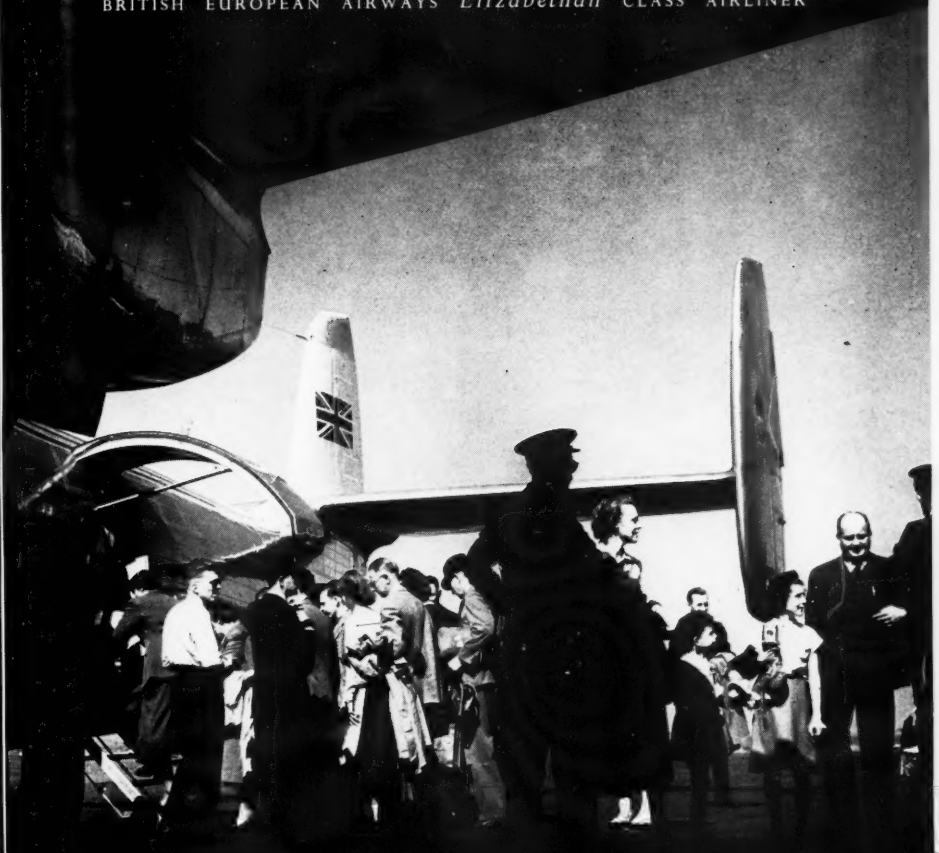

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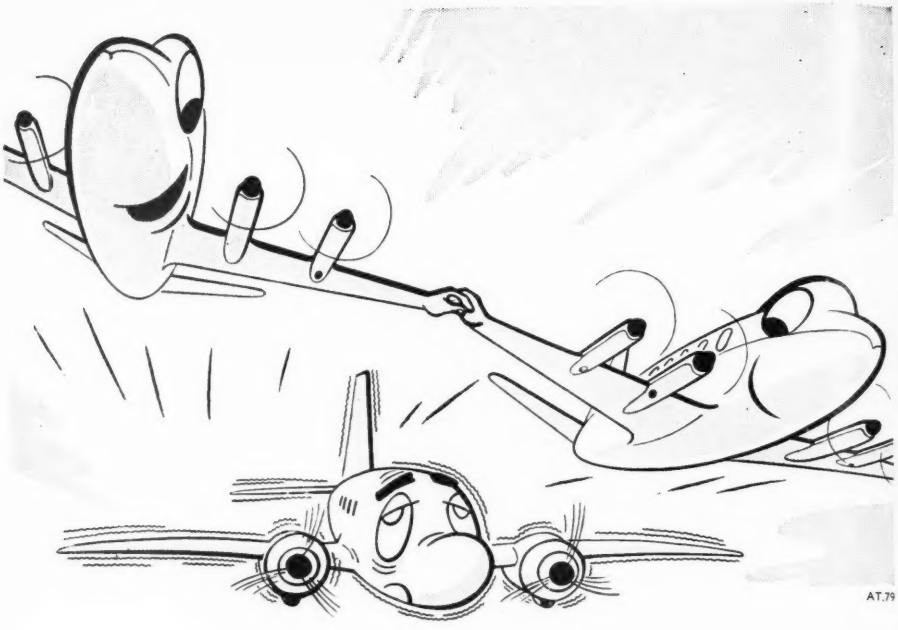

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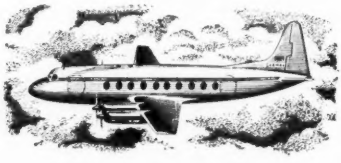

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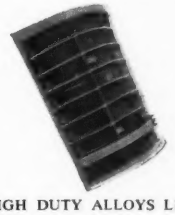

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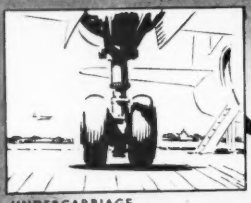
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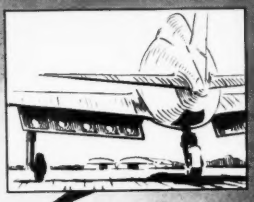
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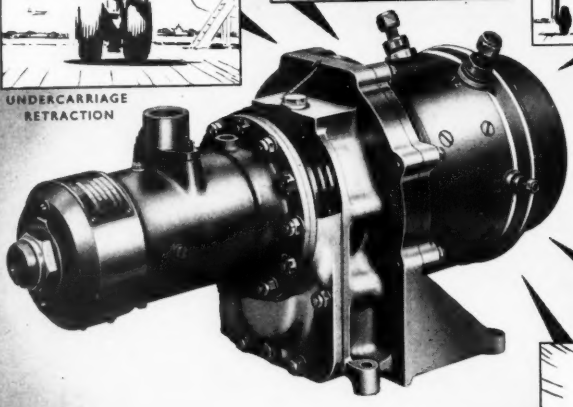

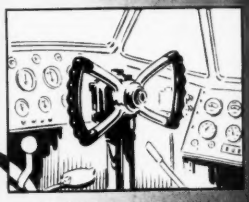
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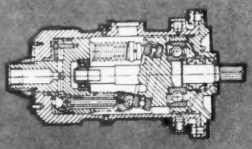

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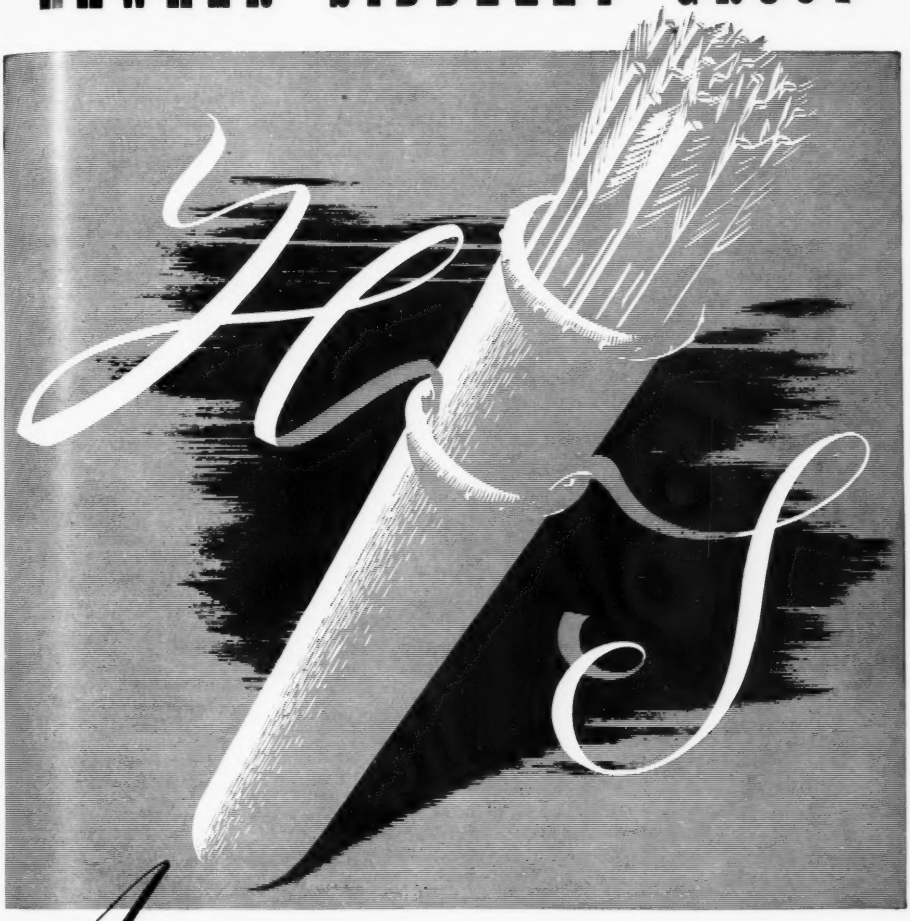

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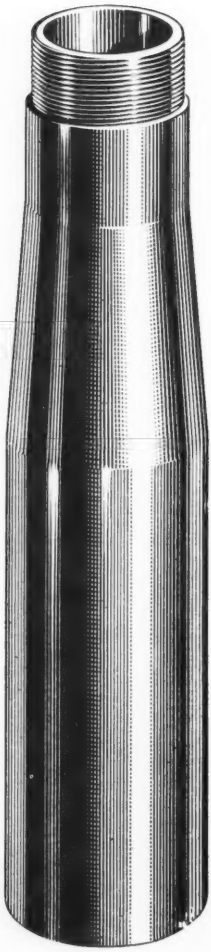

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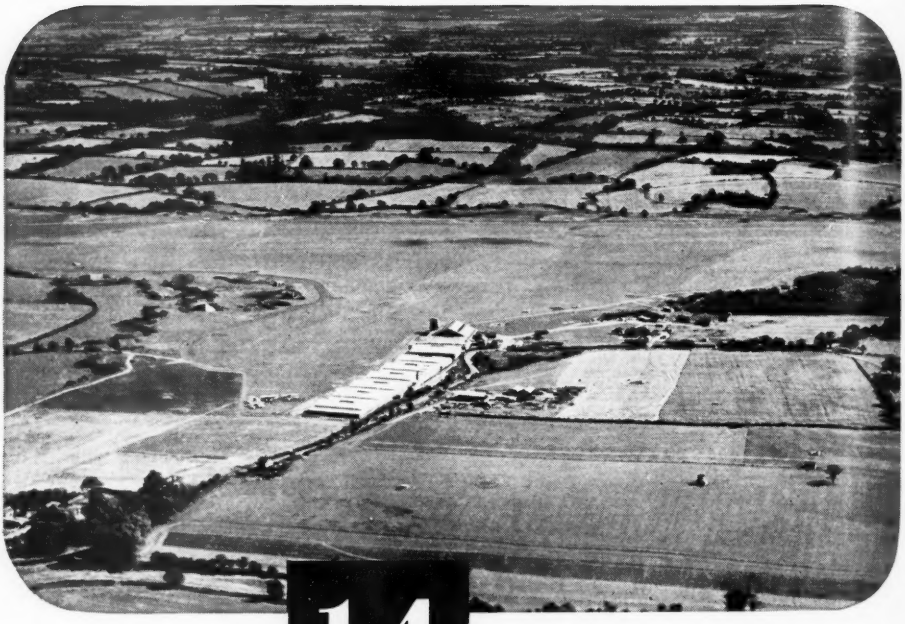
Unless an abbreviation is one recognised as standard practice, both in this and other English-speaking countries, for example b.h.p. for brake horse power, the meaning should be given in full on its first use.

Do you know your airfields?



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THE THIRD ANGLO-AMERICAN CONFERENCE brought, for the first time since these Conferences began, a full-grown realisation of their importance in fostering that close technical co-operation and understanding upon which the freedom of human relationships must ultimately depend.

From the opening words of the President of the Society, Major F. B. Halford, C.B.E., until the closing speech of Admiral Richardson, President of the Institute of the Aeronautical Sciences, there was that warm friendly spirit of co-operation which made this Third Conference the most successful yet held, and set a pattern for the future.

Many of the 540 delegates were accompanied by their wives and families, who added greatly to the pleasure of the social functions which had been arranged.

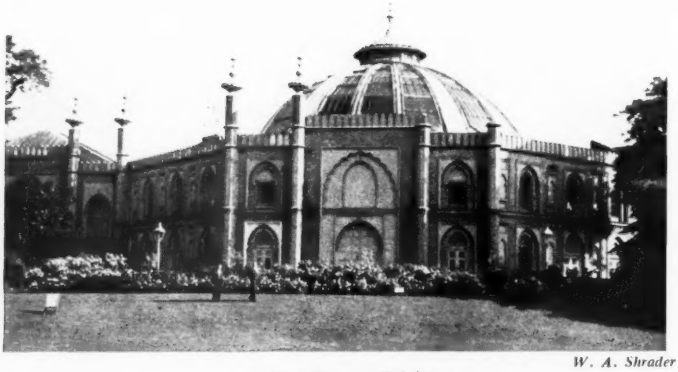
There is little doubt, looking back on the Conference week at Brighton, that the Royal Aeronautical Society and the Institute of the Aeronautical Sciences can play—indeed must play—a large, if not a major part, in building a strong aeronautical Atlantic highway along which, in both directions, will fly those concerned with research, design, construction and operation of aircraft in all its forms.

In Brighton the American and British delegates were not only closely associated in the papers which were read and in the technical discussions, but they were accommodated in hotels within easy walking distance of one another, so that they could continue their discussions and make full use of the precious time at their disposal. The Society itself had an office in the Grand Hotel, the Conference headquarters, and both American and British delegates were able to obtain the information which they required on the spot. The two previous Conferences had shown how difficult it was to achieve such a closely knit organisation and the constant contacts of the delegates in London and New York, and there is no doubt that the choice of a smaller town contributed greatly to the happy spirit of the week.

The unique Royal Pavilion in which the delegates and their ladies were the guests of the Mayor and Mayoress of Brighton, Alderman and Mrs. Simms, the many examples of the fantastic Regency period in the town and its famous Lanes, and the coach tours of Sussex organised each day for the ladies and those delegates who were not attending a particular paper, provided a fusion of historical interest and pleasure which made a special appeal to our American visitors.

It is a tribute, indeed, to the success of the Conference, both technically and socially, that members of the Councils of the Society and the Institute, early in the week held informal discussions for the time and venue of the Fourth Conference in 1953 in the United States of America.

The pages which follow contain a selection of photographs, a Diary of the Conference, reports of the speeches at the Opening and Closing Sessions and at the Conference Dinner, with a verbatim report of Lord Brabazon's important speech, summaries of the 20 papers and lists of the delegates and their wives.



W. A. Shrader

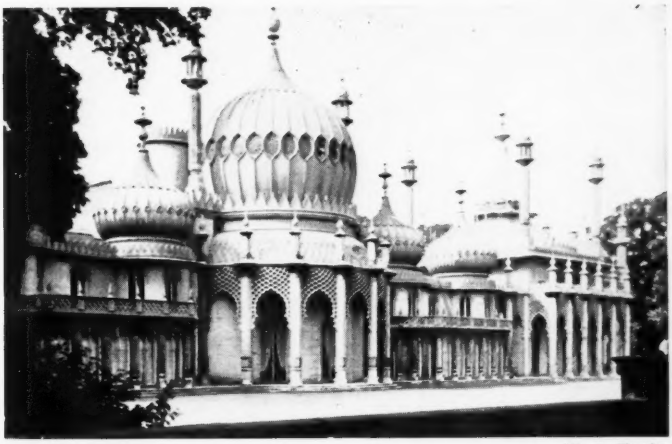
The Dome, Brighton.

Artco

Lunch was served for the delegates in the Corn Exchange on each of the full-day sessions, and many were the discussions around the lunch tables. In the foreground here may be seen on the right Major R. J. Mason, R. R. Dexter, Paul Johnston, Admiral Richardson, and on the left, R. A. Shaw. Among those recognisable at the table are Ivan H. Driggs and A. G. Elliott.

Included in this group are C. G. Grey, Captain J. J. and Elmer Sperry.

Lunching together are Major G. P. Bulman, Gr Captain Clarkson, P. G. Masefield, A. E. Raymond, B Shenstone, P. B. Taylor, Sir Roy Fedden and Adm Richardson.

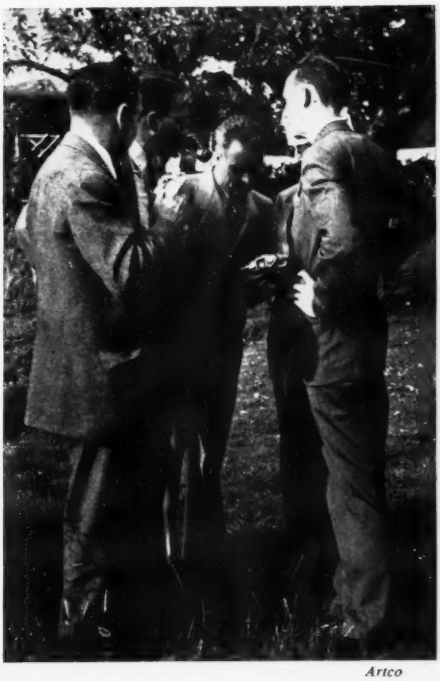


W. A. Shrader

The Royal Pavilion, Brighton.

Artco

On one of the coach tours, exploring Sussex.



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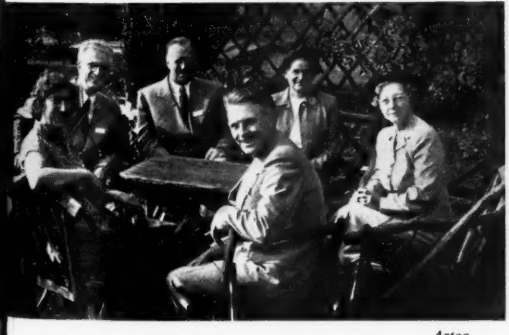
Discussing cameras. R. W. Young, Dr. J. J. Green, Dr. T. P. Wright (just visible), W. R. Enyart—and friend!



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In a Sussex garden, at the Shelley Arms, Nutley. This group includes Dr. T. P. Wright, Leroy Grumman, Mrs. Grumman, Mrs. Wright and Dr. J. J. Green.

DIARY OF THE CONFERENCE

MONDAY 3rd SEPTEMBER

Reception at the Grand Hotel. Delegates and their ladies were received by the President of the Royal Aeronautical Society, Major F. B. Halford, C.B.E., F.R.Ae.S., and Mrs. Halford, and by the President of the Institute of the Aeronautical Sciences, Admiral L. B. Richardson, F.I.A.S., U.S.N. (Retd.), and Mrs. Richardson.

TUESDAY 4th SEPTEMBER

Official opening of the Conference at the Dome, 9.15 a.m.

Lectures—10.45-12.30, 2.30-4.00, 4.30-6.00 p.m.

Coach Tour: An afternoon tour to Beachy Head and Eastbourne, by way of Newhaven, Seaford, Cuckmere Valley, Friston, Berwick and Firle.

WEDNESDAY 5th SEPTEMBER

Lectures—9.00-10.30 a.m., 11.00-12.30, 2.30-4.00, 4.30-6.00 p.m.

Coach Tour: A full day tour to Hastings, Winchelsea and Rye, by way of Pevensey Bay, Bexhill, Northiam, Bodiam, Cross-in-Hand, Ringmer and Lewes.

Reception and dance given by the Mayor and Mayoress of Brighton at the Royal Pavilion.

THURSDAY 6th SEPTEMBER

Lectures—9.00-10.30 a.m., 11.00-12.30.

Coach Tour: An afternoon tour to Ditchling and Crowborough by way of Ashdown Forest and Nutley.

FRIDAY 7th SEPTEMBER

Lectures—9.00-10.30 a.m., 11.00-12.30, 2.15-3.45, 4.15-5.45 p.m.

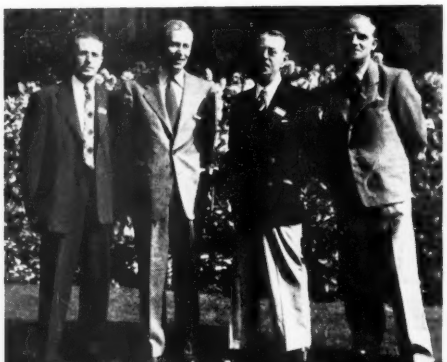
Closing ceremony at the Dome, 6.00 p.m.

Coach Tour: A full day tour to Arundel and Chichester, by way of Devils Dyke, Cowfold, Pulborough, Amberley, Washington Pines, Steyning and Bramber.

Conference Dinner.

SATURDAY 8th SEPTEMBER and SUNDAY 9th SEPTEMBER

A visit to Stratford-on-Avon was arranged for American delegates and their families. A party of about 80 left Brighton by coach early on the Saturday morning and arrived at Stratford early in the afternoon. In the evening they attended the performance of *Henry V* at the Shakespeare Memorial Theatre. The following morning they left Stratford, and after having visited Oxford, arrived in London about 6 p.m.



From left to right: R. R. Dexter (Secretary, Institute of the Aeronautical Sciences), S. Paul Johnston (Director of the Institute), Captain J. L. Pritchard (Conference Secretary) and Dr. A. M. Ballantyne (Secretary, Royal Aeronautical Society).

Artco

At the Royal Pavilion—Major F. B. Halford, Mrs. Richardson, His Worship the Mayor of Brighton Alderman Eric Simms, the Lady Mayoress Mrs. Simms, Mrs. Halford and Admiral Richardson.

THE CONFERENCE DINNER

The final event of the week was the Conference Dinner, held at the Grand Hotel on the 7th September and attended by more than 400 Delegates and their ladies.

The following is a report of the speeches made at the Dinner, with a verbatim report of Lord Brabazon's speech.

W. A. M. BURDEN, M.I.A.S., Past President of the Institute of the Aeronautical Sciences, proposed the toast of "The Royal Aeronautical Society":—

There were two great sensations which were experienced at these joint meetings. The first was the feeling of appreciation in the co-operation which existed in the Anglo-American effort. The second, and of more long term significance, was the appreciation of the creation of a tradition in the still fairly new field of aeronautics. The year 1866, which had marked the creation of the Society, might seem to be a long time ago, but it was relatively recent in terms of the history of civilisation. The first Anglo-American Aeronautical Conference occurred but four years ago. The progress made in that short time in giving a feeling of solidity and continuity to their joint meetings had been a credit to the British genius for building traditions. It had been accomplished by an appreciation of the great importance of aviation in the service of man, by the exercise of intelligence, by a sense of humour and a willingness to co-operate where co-operation was essential.

The application of those qualities had built a great tradition which was symbolised by this joint meeting. Toasting the Society, proven by a long record of achievement, creator of a unique tradition, he and his colleagues were proud to share in the joint crusade for the protection of the free world.

MAJOR F. B. HALFORD, C.B.E., F.R.Ae.S., President of the Royal Aeronautical Society, replied to the Toast:—

He thanked Mr. Burden for his kind remarks. Mr. Burden was Special Assistant to the Secretary of the United States Air Force and had done a great deal for American aviation and the Institute of the Aeronautical Sciences in particular. They were fortunate in having him with them tonight.

He and Admiral Richardson had received a cable from an old friend, Lester Gardner, sending his best wishes and regrets that he was not with them.

He had also received another message from an Honorary Fellow of the Society, one who was as well known in America as in England. It was:

From THE RIGHT HONOURABLE WINSTON S. CHURCHILL.

It gives me much pleasure, as an Honorary Fellow of the oldest Aeronautical Society in the world, to learn of the lead it has taken over the years, with the Institute of the Aeronautical Sciences of America, to foster the closest technical co-operation between this country and the United States in the whole field of aerial development.

These Conferences between the leading aeronautical technicians of the United States and the United Kingdom increase that understanding and friendship which are vital for successful partnership in our struggle for the way of life which is our common heritage.

I wish you well in your deliberations.

WINSTON S. CHURCHILL.

What a typical Churchillian epitome of what must be in the minds of them all that night!

Wilbur Wright and others like that "Penetrative Pioneer of Power Progress"—Lord Brabazon, whom he was delighted they would hear later—did not have "world conquest" in mind in their pioneering days, yet each year the world's future appeared to depend on what was achieved in aviation, and by whom.

Few people appreciated the vital, if minute, part played by British and American technicians in fostering and sealing friendship between the two countries.

The First World War had ended with but a poor understanding between them, but they forgot what had been achieved and the milestones which marked their progress. They included the valuable seeds which had been sown by the Schneider Trophy races, especially in 1924. In 1926 a series of British visits to the United States had begun and been followed by a crop of American visits to these shores. The Wilbur Wright Lectures, followed by dinners, had started; the MacRobertson Race to Australia with new American and British machines competing, incidentally at the same time putting the hall mark on the superiority of the monoplane. Then Ted Wright's 1938 lecture on Aircraft Production had created great interest on both sides of the Atlantic. Finally, the advent of the gas turbine speeded up that "getting together" policy which culminated only recently in providing the last jewel in that Technical Tiara of trans-Atlantic co-operation.

It was the late Bernard Shaw who said that "Britain and America were two countries separated by the same language." How true that had often been. They treated one another *en masse* more like relations, sometimes, than friends, although individually they had so much in common.

But they were different, in background, population, climate, methods of education, resources and even in type of government and all those had a profound effect on what each could do best. In this "war-fearing" world they ought to thank their lucky stars—and stripes—that they were so complementary.

Perhaps the British character made them sometimes excel at the initiation of new developments; the Americans certainly excelled at the courageous exploitation and production of such projects, but what a combination if used to the common good!

As a member of the Aircraft Industry, who took a fairly intelligent interest in power plant problems in particular, at times he felt that there was not the complete two-way technical traffic between them that there should be.

If not watched carefully, "Security" could become a bogey. The faster the technical progress, the less damage leakages could do and the way to defeat the copyist was to move faster still. To move faster there must be co-operation wherever possible. If between them they could work to remove whatever barriers, visible or invisible, real or imagined, which now prevented their bringing out the best in one another, both forebearing to merely follow or imitate—then, as Mr. Churchill said, it would be "a successful partnership in our struggle for the way of life which is our common heritage," and the closer the two Societies worked together, the more successful would be that partnership.

LORD BRABAZON

LORD BRABAZON of Tara, M.C., Hon.F.R.Ae.S., M.I.A.S., proposed the toast of "The Institute of the Aeronautical Sciences":—

I am obeying the instructions of the President of the Royal Aeronautical Society—and I always obey a president—and propose with a sense of pleasure and honour the toast of "The Institute of the Aeronautical Sciences," with which is coupled the name of its President, Rear-Admiral Richardson.

I am delighted that the Mayor of Brighton, Alderman Eric Simms, is present on this occasion, accompanied by the Mayoress, Mrs. Simms. I am very pleased to be back again in Brighton because I attended school here. That reminds me that I have a bone to pick with the Mayor, for I remember that in my schooldays it was the practice of older people to travel along the front in a bath chair—a three-wheeled vehicle pushed by a man of more than 90 years of age at a speed of about one mile per hour—and I had hoped that when I became older I would be able to do that also. But all the bath chairs have disappeared and I just have to walk.

I do not know what the American visitors think of Brighton. I hope they have found it refreshing and that they have had opportunities to go into the hinterland, for Sussex is a most charming county. Later, at their leisure, they will read the papers that have been presented to the Conference. Those papers contain good stuff; in the words of one of America's immortal authors, Mark Twain, "If you like that sort of thing, that is the sort of thing you like."

The charm of aeronautics is its restlessness; it never remains stable or static for five minutes, but is always on the change. The only people who do not want a change are, of course, the operators! All forms of operators, whatever they operate, want something they know all about, something which has been running for years, and anything new is anathema to them. However, the Industry has pushed down their throats a lot of new machines lately, which is very satisfactory.

I hope that, on the military side, those engaged in aeronautics will not consider themselves as representing just one branch of science or one branch of the Services. They are more than that. Unless we can maintain technical superiority in the air we will be beaten if war occurs; nothing is more important, for if we are once beaten in the air we are a beaten nation. That is why the urge to produce the finest machines in the world is one of the most important things to be done at the present time.

The fact remains, however, that aeronautics is almost obsolescent and is rapidly becoming true ballistics. Already a planetary society has started in London. A sort of newspaper is produced once a month, containing most attractive information, and indicating which planet is the most attractive to stay on for a short holiday. Recently I have been talking to my friend, Mr. Hubble, the great astronomer, and have had with him some cosmological chats. He has talked of producing the perfect vehicle in which to travel to the moon, or elsewhere. In interstellar space, however, especially moving around the sun, there are particles of matter varying from the size of a golf ball to that of Ellis Island, and travelling rather faster than a bullet. The chances are about three to one against the vehicle being hit. I have reluctantly come to the conclusion that I am not going to the moon; no doubt winter sports there are very admirable, but St. Moritz for me!

The great Prince Bismarck remarked, in about the year 1875, that the most significant thing in the world was that Great Britain and America spoke the same language. That phrase about speaking the same language has a narrower meaning today, but it is just as powerful as it ever was. It is indeed of transcending importance.

I recall the first meeting of P.I.C.A.O., when I led the British team. That team was seated at a very cosmopolitan table opposite the Americans, and I felt that they were about the toughest lot of guys I had ever seen. No doubt they thought the same of the British team; and we scowled at each other. I had to make the first speech, and I stated very plainly that the British were not going to be bullied by the Americans; in return, they said they were not going to be coerced by anybody from Britain. Then we formed committees. The admirable institution known as "elevenses" was of great benefit, for we all drank coffee together. After about two days we were calling each other by our Christian names and ever since then we have been devoted friends. As a result of the creation of that spirit, many technical problems which arose were resolved by personal letters between friends.

Americans love America, and there are many English people who also love America. I wish there were more facilities for English people to go there; the exchange control makes it very difficult for us to do so. It is very refreshing for an Englishman to arrive in America; one is impressed by the invigorating freshness of life there, by the lack of cobwebs. The people there are of the kindest and sweetest in the world. Some British people have gained impressions which are quite erroneous, from the cinema, such as that there are gangsters shooting each other at every street corner. On one occasion, on a journey from Toronto to Rochester, I met an Immigration Officer who I thought would be rather difficult. But in fact that officer proved to be the nicest man I ever met; we dined together, and we still send one another Christmas cards.

What wonders you have accomplished in America relative to aviation, and is it not right that you should so do for it was in America that flight was born!

There are people here tonight at this dinner who knew and loved both Wilbur and Orville Wright, and we are proud to think that in their turn they had an affection for us, for did not their first machine rest in our great Science Museum for over twenty years; the most marvellous museum-piece in the world.

What pleasure it gives us to see you here! We marvel at your technological progressiveness, unrivalled in the world, pressing along at bewildering speed.

I wonder what you will think of us in your hearts, from a technical point of view. Comparisons are odious, consequently all we wish to hope is that you will consider us a worthy yardstick by which you can measure your own achievements.

You technicians from both countries will get on well together; you speak the same language, this time in the second sense, but I wonder what you will think of the people of this country and what you will tell about them to your friends on your return?

You will, perhaps, remind them that this country was once the greatest, proudest and the richest country in the world. Two wars, not of our own making, have bled us white. We sacrificed the best of our manhood which should now be taking charge of the country, in the Battle of the Somme and other battles of the First War, and our vast treasure has now been dissipated. This country is not used to living on charity, but it has done so on yours for many years. What help and understanding has been given by you, and with such grace and so openhandedly! Never in the history of the world has such generosity been shown, as has been done by the United States.

Not only are you great geographically, but you are great in spirit. Look at the recent Peace Treaty with Japan. After the treachery inflicted upon you, the horrors that you have endured and the loss of life it cost you to win, you have returned, in the Peace Treaty, good for evil. Surely there cannot be one citizen of the United States who is not proud, and rightly so, of his country.

You, to your friends will tell that you have seen a country here, down in the dumps a little, not seeing things very clearly, having lost, for perhaps a time, their old political wisdom, but at heart, sound. You will tell them that there have been bad times before and they got over them and will do so again. But there is one tremendous change that has taken place; gone forever is that idea of Great Britain living in splendid isolation for the reason that she is an island. The old Blue Water School has died. When Bleriot crossed the Channel the whole geographical situation changed; we are now just the last bit of Western Europe. The Channel has disappeared and the great Atlantic is becoming less and less of a barrier to be crossed and the result is that it is at last realised, I believe, both here and in America that our destiny and yours are forever linked together. We have the same heritage and the same way of life, the same love of freedom and the same love of initiative and independence and there are none here or in America who would not rather perish than tolerate the introduction of the "police state." You will, perhaps, tell your friends these things about this small island, saying that they are at the moment perhaps harassed and perplexed, but will you end up with this note? That, small as we may be, we have been in the past, and we intend to remain in the future, for ever "Great" Britain.

I give you the Toast of the Institute of the Aeronautical Sciences, and ask you to drink to our dear friends who compose it; I couple this Toast with the name Admiral Richardson.

ADMIRAL L. B. RICHARDSON, F.I.A.S.:—The honour of responding to the toast was one of which he felt extremely unworthy, and he found it difficult to find words adequate to the occasion; nevertheless, he was happy and proud to accept the honour. One reason was that, while his family had been in the United States for about 300 years, all his forebears came from the British Isles, and it was natural for him to like and admire the British. Again, he was proud to have been made a Commander of the Order of the British Empire after the 1939-45 War; he wished he were wearing it that evening.

Throughout the past week he had enjoyed the atmosphere of friendliness which had permeated all the various gatherings, both technical and social. He had been impressed with it even more than he had expected, even though he was aware of

Tasker

(*Left to right*): Preston R. Bassett, who was President of the Institute of the Aeronautical Sciences at the first Conference in 1947, Mrs. Richardson, Admiral Richardson and Mrs. and Mr. Paul Johnston.

the good fellowship that was created by the first such conference in Great Britain in 1947, and which was enhanced two years ago in the United States. That spirit of friendliness would continue to increase as they continued with those conferences and became even better acquainted. Having observed those meetings very carefully, he was certain that they were an excellent augury for the future.

On that theme he would read again the message received from President Truman, which was read at the Opening Session of the Conference, and which stressed understanding, collaboration and the strengthening of the bonds which existed between them. Friendliness was the best basis for all of those. The longer he lived, the more experience he gained, the more he saw of this world, the more strongly did he agree that the most essential thing today—and it would remain so during their lives, without exception—was the friendship, understanding and co-operation between their two nations. They must foster and preserve it.

It was also vitally important for those in the aeronautical engineering profession and in the sciences related to aeronautics to continue to show that they were united. Standing together in aeronautics, nothing could defeat them in any other field.

The Institute of the Aeronautical Sciences would be only 20 years old in January 1952; the Royal Aeronautical Society would then be 86 years old. But although the Institute was young, it had the enthusiasm of youth, and hoped it was not guilty of the faults of immaturity. It looked up to its parent Society with respect and would always value its assistance.

The visitors from the United States, together with their British friends, had enjoyed the hospitality of the Mayor and Mayoress of Brighton, Alderman and Mrs. Simms, and took great pleasure in their presence at dinner that evening. He had read in the Conference Handbook that neither Queen Victoria nor Prince Albert had found pleasure in Brighton; the visitors from the United States, however, had derived very much pleasure there.

He expressed again his real respect and admiration for Lord Brabazon, and thanks for his eloquent and kind remarks, which were reciprocated by all.

S. PAUL JOHNSTON, F.I.A.S., A.F.R.Ae.S.:—He expressed on behalf of the entire American group appreciation for the magnificent job done by the Royal Aeronautical Society, and by their old friend Laurence Pritchard.

Laurence Pritchard was an old personal friend and he was too badly prejudiced in his favour to be an entirely reliable witness, but he was somehow reminded of a bit of verse from Lewis Carrol. Taking some liberties with the text they might imagine a conversation (many years from now) which could run as follows:

> "You are old, Captain Pritchard," the young man said,
> "And your hair (what's left of it, that is) has gone very white,
> *And yet you continually stand on your head,*
> Do you think, at your age, that is right?"
>
> "In my youth," said the Sage (that is, up to my 80th birthday!)
> as he shook his grey locks . . . ."

"Now see here, chum," he goes on, "let's stop messing about with this poetry nonsense. The fact of the matter is that after dealing with Americans on both sides of the Atlantic for so many years I got in the habit of looking at things *their* way—AND I SIMPLY CAN'T STOP IT!"

They loved Laurence Pritchard as an old friend. It had been invaluable to have him visit America in January and to work out with them the details of the Conference. On behalf of the entire American delegation he congratulated him on his superb generalship in organising matters in America and in London. But generalship was not enough; such things were not done single-handed and no general in the world had ever done a successful job without a good staff.

So far he had deliberately refrained from mentioning Captain Pritchard's successor as Secretary of the Society—Dr. Ballantyne, in whom all had found a

new friend. As Director of the Institute he assured him that all concerned with that organisation pledged him their full co-operation, that they would assist him in every possible way in the work he had undertaken.

They were already discussing plans for the 1953 Conference and he hoped that most of those who were at the Brighton Conference would visit America on that occasion.

CAPTAIN LAURENCE PRITCHARD, C.B.E., Hon.F.I.A.S., Hon.F.R.Ae.S.: He thanked Paul Johnston for his kindness in his praise and the praise of the staff of the Society. He was anxious to pay his tribute to the President of the Society, Major Halford, and to Mrs. Halford, for the example they had set him that week, an example of fine courage which he would always remember. Both had known only two days before the Conference began that the President would have to undergo a throat operation immediately the Conference ended.

He had an apology to make to the Mayor of Brighton, because at the reception in the Pavilion the Mayor had asked him if he knew anything about Brighton in connection with aeronautics, and he had replied he knew of nothing. He had learned since that there was a remarkable aeronautical flavour about Brighton which could be linked up with the Conference. In 1912 an American pioneer had come to Great Britain, one Glenn Curtiss, who had had a flying boat and had brought it down at Brighton. Curtiss had taken back with him to America an Englishman named John Porte, who on his return to England, had proceeded to build the biggest "flying" boats of that time. They were very small compared with those of the present day, but they were the grandfathers of the modern Princesses.

Another man to whom he would like to pay tribute was Charles Grey, who had taught him much of aeronautics, and whose presence on that occasion afforded the greatest pleasure to his many friends. It was Charles Grey who had reminded him of Glenn Curtiss. He was the only man in aeronautics, to Captain Pritchard's knowledge, who had always put the "C.G." in the right place!

In conclusion he spoke feelingly of the debt which he owed to all his staff and to his wife over the years, a debt he could not find words adequately to repay.

The dinner was followed by a dance which continued long after midnight.

Tasker

A group taken at the reception following the Wilbur Wright Memorial Lecture, which includes B. N. Ashton, G. R. Edwards, Mrs. Grumman, Leroy Grumman, Mrs. Edwards, Air Chief Marshal Sir Ralph Cochrane and Mr. and Mrs. Paul Johnston.

Artco

Major F. B. Halford, C.B.E., President of the Royal Aeronautical Society, addressing the Delegates at the opening of the Third Anglo-American Aeronautical Conference. With him on the platform in the Dome were the President of the Institute of the Aeronautical Sciences, Admiral L. B. Richardson, the Mayor of Brighton and officers of the Institute and the Society.

THE TECHNICAL SESSIONS

The Opening Ceremony

Promptly at 9.15 a.m. on Tuesday 4th September, the delegates gathered in the auditorium of The Dome for the official opening ceremony. On the platform were the Mayor of Brighton, Alderman Eric Simms, the President of the Royal Aeronautical Society, Major F. B. Halford, the President of the Institute of the Aeronautical Sciences, Rear Admiral L. B. Richardson, the Director of the Institute, S. Paul Johnston, the Secretary of the Institute, R. R. Dexter, A. E. Raymond, past President and E. E. Aldrin, Treasurer of the Institute, G. H. Dowty and G. R. Edwards, Vice-Presidents of the Society, Dr. A. M. Ballantyne, Secretary of the Society and Captain J. Laurence Pritchard, Conference Secretary.

Major Halford presided, and after apologising for his voice, which he hoped would be audible with the help of the loud speakers, introduced the Mayor.

THE MAYOR, ALDERMAN ERIC SIMMS:—He welcomed the delegates and said that Brighton took great pleasure in being the venue of so important a conference. When a conference came to Brighton every Mayor tried to connect the town with the particular conference, but how to connect Brighton with aviation he did not know. It was a part owner of Shoreham Aerodrome but the less said about that the better; since the beginning of the Second World War they had not seen it.

But Brighton had facilities to offer the Conference. The Dome was an historic place, and he looked forward to receiving the delegates as his guests at the Royal Pavilion.

The Conference programme almost alarmed him, there were so many lectures; but he hoped that the delegates would find time to see something of the town and of Sussex and would enjoy their visit.

He paid tribute to Captain Pritchard, with whom representatives of the Corporation had had several meetings and who had worked so hard to make the Conference a success.

MAJOR HALFORD:—After thanking the Mayor for his kind remarks he welcomed the delegates on behalf of the Council of the Society and referred to the growth of the Conferences; in 1947 some 42 American delegates and 10 ladies had come from America, in 1949 the British contingent to America totalled 47, and today 150 American and 540 British delegates and wives were attending. He was particularly glad that so many delegates were accompanied by their wives and families.

The following message had been received from the Prime Minister:

From THE RIGHT HONOURABLE CLEMENT R. ATTLEE, Prime Minister.

I welcome and wish every success to the Third Anglo-American Aeronautical Conference. I welcome it because I believe the constant interchange of knowledge and ideas must ultimately be for the everlasting benefit of the world. I wish it success in its efforts to solve some of these problems so urgently awaiting solution for the safety and comfort of this vital form of transport.

C. R. ATTLEE.

He paid tribute to the Mayor and Corporation of Brighton for the co-operation and support given in every way to Captain Pritchard, and to the Institute of the Aeronautical Sciences for all their assistance which had been so freely given.

He hoped that from the Conference itself and from the social arrangements which had been made the delegates would not only profit technically, both inside and outside the Dome and the Corn Exchange, but that they, their families and friends, would look back on Brighton with genuine pleasure.

His hope was that the lectures would prove to be fertile and the discussions fierce and frank, but friendly!

ADMIRAL RICHARDSON:—This was the third of the Anglo-American Aeronautical Conferences and it might well be considered the first conference of the second cycle, the conferences in 1947 and 1949 representing the first cycle. Those first two conferences were more or less experimental. But he believed the success which they had attained and the popularity and prestige they had achieved were such that the conferences should be a permanent institution; certainly he and his colleagues in the United States hoped that the cycle would be continuous from now on.

As a further indication of the prestige which the conferences had achieved, the following messages had been received from the President of the United States, from the Secretary of the U.S. Navy and the Secretary of the U.S. Air Force:

From THE PRESIDENT OF THE UNITED STATES.

A complete understanding with the people of Great Britain at all levels is of the utmost importance in these times of world crisis. In the field of aeronautical sciences the closest possible collaboration is highly desirable. For this reason I hope that the third Conference between the Royal Aeronautical Society and the Institute of the Aeronautical Sciences will strengthen the bond that already exists between the aeronautical engineering professions on both sides of the Atlantic. I wish the Conference every possible success.

HARRY TRUMAN.

From THE SECRETARY OF THE UNITED STATES AIR FORCE.

The importance of aviation to the preservation of democracy and peace grows greater with every advance made in the aeronautical sciences. Not only the peoples of Great Britain and the United States, but mankind in general should benefit from the exchange of information at the Third International Conference of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society of Great Britain. On behalf of the United States Air Force, I send all good wishes for the success of the Conference.

THOMAS K. FINLETTER.

From THE SECRETARY OF THE UNITED STATES NAVY.

On behalf of the United States Navy, I send greetings and congratulations to the Third Anglo-American Aeronautical Conference. The spirit of friendship and willing co-operation which has always marked the relations between the Royal Aeronautical Society and the Institute of the Aeronautical Sciences has, I believe, been given its strongest and most effective expression in these joint conferences. The opportunities for meeting and freely discussing recent noteworthy aeronautical work and for making enduring friendships among those engaged in that work, on both sides of the Atlantic, will continue to have a profound effect on our mutual aeronautical progress. We in the Navy, realising that the future welfare of both of our great countries may well depend upon such progress, extend to you our every wish for a most successful conference.

DAN A. KIMBALL.

He was particularly anxious to pay tribute to the splendid staff work which had been done by the Royal Aeronautical Society. The American delegates had been most impressed by the completeness and perfection of the arrangements made, including among many other things the preparation of 20 papers in a form in which they could be distributed to everyone concerned before the Conference began. As there were some 150 visitors from the United States requiring information, changing their programmes, and so on, there were many permutations and combinations of problems to be handled. A large part of the success was due to the work of Captain Pritchard, the Conference Secretary, and to him he paid particular tribute. Captain Pritchard was practically one of the founders of the Institute of the Aeronautical Sciences, having given the founders sound advice, guidance and help at the time of its birth, and having guided them through the subsequent years by the application of his long experience and excellent judgment. They considered him one of their friends, as he would be always, although his days of activity in the Royal Aeronautical were practically over.

He invited as many people as possible from Great Britain to visit the United States for the next conference in the series, which would be held there in 1953, the year which would mark the fiftieth anniversary of the first flight of a heavier-than-air machine. He and his colleagues hoped and believed that on that occasion they could offer an interesting programme; it would also be a real pleasure to them to return the hospitality extended to the Americans in this country.

The delegates then adjourned to the Corn Exchange where the lectures were held. The following places on record summaries of the 20 papers.

TUESDAY, 4th SEPTEMBER

MORNING SESSION

Advances in Aircraft Structural Design—G. T. R. HILL, Consulting Engineer to Short Brothers and Harland Ltd.

Chairman: Rear Admiral L. B. Richardson, U.S.N. (Retd.), President of the Institute of the Aeronautical Sciences.

The influence of the pioneers in Great Britain of a hundred years ago, Henson and Stringfellow, was traced through the early experiments with gliders to the Wright brothers and their first successful flights.

An explanation was put forward of the many fatal cases of structural collapse which befell monoplanes just before the First World War; knowledge obtained in recent years indicated that these failures were probably due to aeroelastic effects.

The development of metal skin as a practical possibility was traced and the various methods of stabilising the skin so as to form an effective structure, as well as a satisfactory aerodynamic shape, were touched upon.

The usefulness of the figure of structure weight percentage was discussed, and the broad conclusions reached that structural engineers are more successful than in the past at producing structures of low weight, and that large size is not, as was commonly thought in the early days, defeated by the square-cube law.

The effect of gusts on structure weight was touched upon, and the possibilities of gust-alleviating devices set out.

Fast flying has led to sweepback of both wings and tail, and many aeroelastic difficulties are intensified by this change in structural design. Various manifestations of aeroelasticity, loss of control at high speed, divergence, and flutter were described, together with the methods at present used to keep structural distortions within manageable limits.

Suggestions were made which might avoid some of the weight penalties which appear likely to afflict high-speed designs of the immediate future. A so-called "aero-isoclinic" wing was described, having the property of maintaining its tip incidence when loaded, although swept back to any degree required; and for very heavily swept designs the possibilities of sweepback variable in flight were set out.

An appeal was made for a more open-minded approach towards new ideas in aeronautics.

AFTERNOON SESSIONS

Infusion of Safety into Aeronautical Engineering Curricula—JEROME LEDERER, Director, The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University.

Chairman: Major G. P. Bulman, Director for Construction of Research Facilities, Ministry of Supply.

The gap between theory and practice in aviation engineering has resulted in design errors that have cost thousands of lives and untold millions of dollars. The paper recommended ways to bridge this gap. In addition, it discussed the background of design errors, the problem of stimulating interest in safety and advocated the introduction, as a special course, of the new science of human engineering. Background for design errors were listed as the engineer's ignorance, attitude and subjection to economic pressure. To overcome ignorance five principles of safety were suggested for integration into engineering curricula and these should be supported by specific data at the discretion of the instructor. The five principles were:—

1. Parts or components of the aircraft other than basic structure should be designed to "fail with safety."

2. The structure and its components should be designed to encounter with safety the impact of objects, rough handling by men and the effects of natural phenomena which are likely to be met in service.

3. Procedures for adequate maintenance and operating practices established by the designer should be consistent with average human effort, ability and attitude.

4. The aircraft and its components must be protected against the effects of normally inadvertent or uncontrollable human errors or carelessness.

5. The aircraft should give its occupants reasonable assurance of protection in accidents which are considered to be survivable.

Development in Australia of a Thick Suction Wing—T. S. KEEBLE, Aeronautical Research Laboratories, Commonwealth of Australia.

Chairman: Dr. Hugh L. Dryden, Director, N.A.C.A.

An account was given of the development for flight of a 31.5 per cent. thick GLAS II suction aerofoil; the adaptation of a military glider to accommodate the modified wing was described briefly and the more important results of flight tests of the glider given.

The related boundary layer studies made in the wind tunnel and theoretically, in Australia, during the course of the work were outlined. An application of the aerofoil to a moderately sized all-wing aircraft was examined briefly and the possibility of building a half-scale model of the aircraft in glider form was discussed.

Structural Problems of Future Aircraft—N. J. HOFF, Head of Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Chairman: G. H. Dowty, Chairman and Managing Director, Dowty Equipment Ltd.

The attainment of supersonic speeds has given rise to new problems in aircraft structural design and analysis. Structural arrangements of present types of aircraft, developed for high efficiency at subsonic speeds, have to be altered to make them suitable for good performance in supersonic flight. Problems of a new kind are caused by aerodynamic heating. In the transient state of temperature distribution thermal stresses arise which can exceed the yield stress of the material. Under steady-state conditions creep phenomena attain importance. The latter necessitate a revision of current concepts of structural safety.

These problems were defined and suggestions made towards their solution. Possibilities of improving the materials of construction were pointed out. It was concluded that a rapid development is necessary in aircraft structures in order to take full advantage of recent advances in supersonic aerodynamics and the theory and practice of jet propulsion.

WEDNESDAY, 5th SEPTEMBER

MORNING SESSIONS

Some Problems of Turbine Transport Operation in Europe—K. G. WILKINSON, Project and Development Branch, British European Airways.

Chairman: T. P. Wright, Acting President, Cornell University.

British European Airways' early experience with the propeller-turbine Viscount prototype (V.630) on commercial scheduled services was described, and the more important conclusions on traffic control and aircraft handling were drawn. Prospects for the development of efficient operations with jet and propeller-turbine aircraft using present traffic control systems were discussed.

It was suggested that developments in the near future would occur mainly in the operating practices of the airlines, particularly in matters relating to the flight planning and control of fuel. This argument was developed in detail and a method described whereby more exact calculation of fuel requirements for a route could be made. The corresponding problem of offering payload for sale was examined and a complementary method developed. Operational use of the combined "Variable Booking Payload" method was described and discussed.

The operational performance of existing commercial aircraft on selected routes was analysed and compared with the predictions of the proposed method and the economic consequences for future operations with piston, propeller-turbine and pure jet aircraft were discussed.

It was concluded that optimum operation in present circumstances enable competitive economic results to be achieved with the three types: departure from the optimum, however, could have disastrous consequences with a jet aircraft—so could an increase in fuel costs.

Performance Characteristics of Jet Nozzles—GEORGE S. SCHAIRER, formerly Staff Engineer, Aerodynamics and Power Plant, now Chief of the Technical Staff, Boeing Airplane Co.

Chairman: A. A. Hall, Director, Royal Aircraft Establishment.

The performance characteristics which determine the usefulness of a jet nozzle were surveyed and experimental performance of a number of nozzles was presented, based upon dimensional parameters found in one-dimensional nozzle theory. Several forms of variable nozzles were examined and two experiments with fixed flow were examined to show the nature of inter-actions possible; the field of flow of a jet was examined in the presence of a nearby surface.

It was concluded that most convergent nozzles adhere closely to one-dimensional theory. Expanding nozzles, the mixed flow case, extreme external shapes, the use of simple tabs for changing nozzle area, plug nozzles and the characteristics of double nozzles were considered and additional experiments suggested.

Propellers for High Powers and Transonic Speeds—GEORGE W. BRADY, Director of Engineering, Curtiss-Wright Corporation, Propeller Division.

Chairman: Sir A. H. Roy Fedden.

Propeller developments to increase the forward speed at which propellers may be used have been continuously in progress since the Second World War. Results of tests of a number of different configurations including sweepback, low aspect ratio and low thickness ratio were described from which it was concluded that low thickness ratio was the most important factor.

The effect of applying low thickness ratio to transonic and supersonic propellers was shown to result in good efficiencies for the transonic propeller up to Mach numbers of 0.8 to 0.85 and for the supersonic propeller through the transonic region and well into the supersonic range. Structural and allied problems were reviewed and it was indicated that with high solidity blades made of a high modulus material, such as steel, the desired aerodynamic characteristics could be obtained with a structurally satisfactory design.

Overall performance of a high output turbo-propeller engine with both transonic and supersonic propellers was presented and other important performance advantages of propeller propulsion, such as high take-off thrust and reverse thrust for aerodynamic braking, were outlined.

Plastics and Plastic Structures—J. E. GORDON, Head of Plastic Structures Section, Chemistry Department, Royal Aircraft Establishment.

Chairman: Dr. A. E. Lombard, Jr., Directorate of Research and Development, Development H.Q., U.S.A.F.

The possibility of making large components of a highly integrated nature of plastics which would necessitate radical changes in engineering practice were discussed. Some account was given of plastic structures research at the Royal Aircraft Establishment which represents an attempt to develop a new kind of engineering on these lines and is in many respects parallel to similar American work, although differing in materials and moulding methods.

Materials and methods which have been developed whereby complex mouldings of large size can be made with comparatively cheap equipment and which enable considerable changes in the design of components to be made quickly and easily were described. A series of parallel section wings which are somewhat more efficient than their metal counterpart, and the manufacture of delta wings for flight trials, now well advanced, were described.

Although, weight for weight, the mechanical properties of plastics are somewhat inferior to the better light alloys, it was suggested that, where the torsional stiffness requirement was not too severe, structures as light, or lighter than, metal ones could be made by designing with the particular advantages of plastics in mind.

AFTERNOON SESSIONS

The Reduction of Drag by Distributed Suction—Sir MELVILL JONES, Francis Mond Professor of Aeronautical Engineering, University of Cambridge, and Squadron Leader M. R. HEAD, R.N.Z.A.F., Engineering Dept., University of Cambridge.

Chairman: Preston R. Bassett, President, Sperry Gyroscope Co., Inc.

Recent experiments which have demonstrated the effectiveness and limitations of distributed suction as a means of achieving extensive laminar flow were discussed. Both in the absence of a pressure gradient and in adverse gradients similar to those obtaining over normal aerofoils it has been found possible to suppress normally occurring transition by the use of suction quantities which are sufficiently small to make possible very considerable reductions in overall drag. Extensive laminar flow can be achieved in this way, however, only if regions near the front of the surface are free from such roughness as may be expected to cause transition in the absence of suction. If the considerable difficulties of constructing and maintaining a sufficiently smooth and uninterrupted porous surface can be overcome, then it may be found possible to achieve laminar flow over virtually the entire surface of an aircraft, with far-reaching consequences to the economics of air transport.

A Review of High-Speed Hydrodynamic Development—ERNEST G. STOUT, Assistant to the Chief Engineer, Consolidated Vultee Aircraft Corporation.

Chairman: G. R. Edwards, Chief Designer, Vickers-Armstrongs Ltd.

The free body, dynamically similar model research technique which introduced a new applied science of seaplane hydrodynamics, based primarily upon the concepts of the aeronautical sciences, as opposed to the tenets and philosophy of naval architecture and which has resulted in an extensive programme of hydrodynamic research directed towards the satisfactory water-basing of idealised aerodynamic configurations was discussed.

The paper reviewed the principal design criteria that have evolved during the course of this study and applied these findings to the development of practical water-based aircraft that demand little, if any, compromise with contemporary aerodynamic design. The discussion was divided into the particular requirements for subsonic, transonic and finally supersonic, flight régimes.

It was concluded that the blended-hull, or other suitable aerodynamic forms of high-critical Mach number, could be developed that would exhibit hydrodynamic performance characteristics equal to, or in many cases exceeding, the highest standards of current seaplane design.

THURSDAY, 6th SEPTEMBER

MORNING SESSIONS

Heat Transfer Studies Relating to Rocket Power-Plant Development—LOUIS G. DUNN (Director), WALTER B. POWELL (Senior Research Engineer) and HOWARD S. SEIFERT (Staff Engineer), The Jet Propulsion Laboratory, California Institute of Technology.

Chairman: A. G. Elliott, Joint Managing Director, and Chief Engineer, Rolls-Royce Ltd.

Work relating to the transfer of heat in rocket motors which has been done at the Jet Propulsion Laboratory of the California Institute of Technology was discussed, including a general description of convective and radiative heat-transfer processes in rocket combustion chambers, together with a survey of techniques for

measuring rates of flow of heat and examples of typical data. The ways in which the techniques of external liquid cooling, internal gas and liquid film cooling, and low-conductivity refractory liners may be used to effect an engineering solution to the problem of protecting rocket chambers against heat were also discussed.

A treatment of the phenomenon of convection to liquids at high heat-transfer intensities and the boiling process and the influence of fluid pressure was described, and it was shown that the high rate of removal of heat during nucleate boiling can be explained by detailed study of bubble dynamics. The techniques in which a layer of fluid lines the interior of the combustion chamber, the so-called transpiration or film cooling method was discussed; equations established for the thermal and mechanical parameters of such films were correlated with experimental data.

A new method of describing the turbulent shear stress in the boundary layer was used to develop a relationship for the heat-transfer coefficient for turbulent fluid flow. It was shown that the new theory is an improvement over existing theories and that it can be extended to take into account the variation of physical properties in the boundary layer of the heat-transfer fluid.

Some Aerodynamic Advances—A. FAGE, Superintendent, Aerodynamics Division, National Physical Laboratory.

Chairman: Dr. Hugh L. Dryden, Director, N.A.C.A.

The paper dealt briefly with recent advances that have been made in studies of some aerodynamic problems and illustrated in broad outline the trend of research work on them. Methods of calculating aerofoil characteristics in two-dimensional flow were considered, and an example of the systematisation of experimental section data by relating them to corresponding theoretical quantities was given. A review of methods used for calculating the properties of swept-back wings in steady flow was made and attention was directed to matters of a fundamental nature arising from research work on wings in oscillatory motion, and to the need for experimental checks on the accuracy of theories used to estimate aerodynamic coefficients for oscillatory motion.

General features of aerofoil flow for both high-subsonic and supersonic speeds were considered, and in particular some observed features that differ from predictions made by theory. The dependence of shock-wave boundary-layer interaction on the state of the boundary layer upstream of the wave system and on the Reynolds number of an aerofoil was illustrated. Brief comments were made on progress in studies of transonic aerodynamics, boundary-layer flow (high speed), boundary-layer suction and aircraft air intakes.

Some Material Problems of High Altitude Aircraft—H. W. HALL, Head of Plastics Section, Chemistry Department, Royal Aircraft Establishment, and T. P. HUGHES, formerly Chemistry Department, now Chief Superintendent, Rocket Propulsion Department, Royal Aircraft Establishment.

Chairman: Professor N. J. Hoff, Head of Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

This paper surveyed some of the problems encountered with non-metallic materials in aircraft, including fuels and other fluids, optical and electrical transparencies, rubbers and protective coatings; these problems are caused by the more difficult operating conditions imposed on modern aircraft through high speed and increased operating heights and ranges.

Recent studies of the shortcomings of acrylic polymers as optical transparencies, in particular the nature of crazing, were discussed. The relation between molecular structure of the material and mechanical properties was explained and methods of overcoming inherent difficulties of the plastic as used for aircraft canopies were outlined.

The Aerodynamics of Low-Aspect-Ratio Wings and Wing-Body Combinations—A. H. FLAX (Head), and H. R. LAWRENCE (Assistant Head), of the Aerodynamics Research Department, Cornell Aeronautical Laboratory.

Chairman: S. Camm, Director and Chief Designer, Hawker Aircraft Ltd.

The determination of the aerodynamic characteristics of low-aspect-ratio (<3) wings was considered. Since the curves of lift and pitching moment for such wings show marked non-linear variation with angle of attack, linear lifting-surface theory cannot solve the problem, but it was shown that the predictions of linear theory were in good agreement with experiment at small angles of attack. It was concluded that a proper line of attack was to use linear theory as a basis and to determine suitable additional correction terms for the non-linear effects. Since exact solutions of the lifting-surface integral equation are almost non-existent, and since numerical solutions tend to be laborious, approximations to the lifting-surface equation appropriate to low-aspect-ratio plan forms were investigated. These approximations reduced the two-variable integral equation of lifting-surface theory to a one-variable approximate integral equation. The analogy between the low-aspect-ratio approximations and the well-known high-aspect-ratio approximations of Prandtl and Weissinger was brought out by deriving them all from a common point of view. Comparison of the theoretical lift, moment and pressure distribution with experimental results for rectangular and delta wings showed satisfactory agreement.

The various available theories and empirical methods for predicting non-linear effects on lift were reviewed and compared with experiment. None of these theories or methods dealt with pitching moment. From a study of experimental data and some related theoretical work, it was concluded that viscous effects on the suction side of the wing probably accounted for the major non-linear effects. Comparison of theoretical results for lift and moment with experiments for rectangular, delta and trapezoidal wings having various cross-sectional shapes showed good agreement.

An approximate method for calculating low-aspect-ratio wing-body interference, including the non-linear effects, was presented and shown to be in good agreement with limited experimental data.

FRIDAY, 7th SEPTEMBER

MORNING SESSIONS

Some Research on High Speed Flutter—I. E. GARRICK, Chief of the Dynamic Loads Division, Langley Aeronautical Laboratory.

Chairman: W. S. Farren, Technical Director, A. V. Roe & Co. Ltd.

Various items of research relating to high speed flutter were discussed briefly. The items dealt with, although touching on selected phases of the subject, taken together illustrated the thesis that a many-sided attack is required for the flutter field, and that methods and criteria should be tailored to phenomena. The topics touched on were (*a*) oscillating air forces for Mach number $M=1.0$, (*b*) indicial functions, (*c*) oscillating pressure fields near propeller tips, (*d*) cantilever wing flutter for high speeds, (*e*) flutter of a wing with concentrated weights, (*f*) flutter testing with the aid of rocket vehicles, (*g*) consideration of free body modes and bending stiffness, (*h*) wing flutter for $M=1.3$, (*i*) use of variable medium testing, and (*j*) propeller stall flutter.

Some reference material on static aeroelasticity and some analytical results for wings of very small aspect ratio were given.

Engineering Problems of Aircraft Operation—B. S. SHENSTONE, Chief Engineer, British European Airways.

Chairman: T. P. Wright, Acting President, Cornell University.

Airline engineering problems were considered in a general way from the viewpoints of Development, Maintenance, and other problems.

The necessity for a development staff was considered and the work done was discussed, together with the work of a development group on new aircraft types.

The maintenance problem of improving aircraft, and not only keeping them as good as when manufactured, was discussed and the importance of a good modification system was stressed. The advantages of having only one base were shown, and the necessity for putting maintenance on a production basis like a factory was discussed. Special attention was given to British European Airways (B.E.A.) Prémium Bonus Scheme. Modern trends in overhaul were mentioned and also the pros and cons of outside contract work. The best sort of overhaul basis for an operator, such as B.E.A., was described.

Some attention was given to the general maintenance problem, the sort of work that should be done, how it could be controlled and whether or not there were suitable man-hour targets which could be achieved with fully developed aircraft.

The various methods for doing inspection were described briefly and the problem of engineering standards was considered.

After a mention of a Supplies Department in relation to engineering, the paper concluded with a discussion of engineering stand-by aircraft, and what was considered the worst problem, that of minor unserviceability which delays departures.

Dynamic Stability and Control Research—WILLIAM MILLIKEN, JR., Manager, Flight Research Department, Cornell Aeronautical Laboratory.

Chairman: A. A. Hall, Director, Royal Aircraft Establishment.

A survey of dynamic stability and control research in the United States was presented to indicate the overall developments and progress of recent years. While primary emphasis was placed on methods and techniques, typical results were shown and the more important references cited.

Full scale dynamic response measurements for both control and gust inputs, the prediction of dynamic characteristics, the use of artificial stability in relation to the establishment of rational handling qualities specifications, and special problems such as the stall, the phugoid and spiral modes were discussed.

It was concluded that while a great variety of dynamic research was under way, and progress was being made in devising theoretical and experimental methods for acquiring dynamic data, much remained to be accomplished. While final conclusions cannot be drawn on many of the more technical questions, largely because of the incomplete or exploratory state of the work, there was every evidence that the general results of dynamic research are proving of worth to industry, particularly in connection with automatic and specialised artificial control design. The effects of the rapid growth of dynamic research activity were noted, and the suggestion made that additional surveys and more extensive long range planning were indicated in specific segments of the field.

A number of detailed conclusions were reached on the research work needed and it was pointed out that high priority should be given to research leading to more practical dynamic testing techniques for non-dynamically similar models in conventional wind tunnels.

An Experimental Study of the Static Stiffness and Deformation of Swept Wings with Uniform Chord—A. H. HALL, Research Officer, Structures Laboratory, National Research Council, Canada.

Chairman: Dr. A. E. Lombard, Jr., Directorate of Research and Development, Development H.Q., U.S.A.F.

The paper outlined the results of tests made at the Structures Laboratory of the National Research Council of Canada on the effect of sweep on overall stiffness and deformation including:—

(*i*) Effective length for estimating wing torsional stiffness. (*ii*) Effect of rib direction on torsional stiffness per unit length. (*iii*) Effect of aspect ratio, rib direction and structural length on bending stiffness. (*iv*) Twist due to bending. (*v*) Bending and twist due to distributed loads. (*vi*) An approximate extension to the estimate of bending stiffness for tapered wings.

The eleven cellulose acetate models used covered angles of sweep from −15° to 60° in 15° increments, each angle being associated with two models, ribs normal to the leading edge and ribs parallel to the air stream and the tests described were limited to semi-span wings of uniform chord.

AFTERNOON SESSIONS

The Influence of Size on the Peformance of Turbo-Jet Engines—S. J. MOYES and W. A. PENNINGTON, Projects and Performance Department, National Gas Turbine Establishment.

Chairman: P. B. Taylor, Partner, Sanderson & Porter.

The paper showed how the specific performance of a given design, *i.e.* its weight per unit thrust and fuel consumption per unit thrust, could be affected by change of engine size. It was explained how the influence of size on engine performance arises from Reynolds number effects and from mechanical design considerations. At present, the basic data available to assess these effects rests upon somewhat scanty experimental evidence and experience, and modification to the results obtained is likely as further and more systematic data accrues.

In the analysis, the performance of a family of engines of similar design, covering a range of size, was considered, with allowance made for the effect of Reynolds number upon blade losses. In addition to deriving the performance of each engine, certain assumptions were made which enabled the weight of each engine in the series to be calculated. Thus for any size of engine within the range considered, both its weight and performance might be predicted. The calculations were made to cover a number of typical flight conditions.

On the basis of the tentative assumptions made, the results indicated that for a given application there was likely to be an optimum size of engine, or at least an optimum range of engine sizes, of given basic design, which would yield the lowest total engine plus fuel weight, it being assumed that the number of engines per aircraft was disposable. This optimum size could vary widely according to the flight requirements.

Experimental Methods for Transonic Research—JOHN STACK, Chief of Research, Langley Aeronautical Laboratory.

Chairman: G. R. Edwards, Vice-President, Royal Aeronautical Society.

Experimental methods for investigating the transonic region, rendered necessary by the inability of theory to describe flow fluctuations caused by shock wave-boundary layer inter-action were described. Results of dropped body tests, aided by advances in electronics, and of tests on rocket-propelled models were discussed, together with "wing flow" and "bump" techniques. The rotating disc method was described, together with new support systems in wind tunnels, nozzle design and the open throat tunnel, for reducing the choking range. The co-operative

venture of the U.S. Navy, Air Force and aeroplane manufacturers in producing special transonic research aircraft was discussed.

A comparison of results obtained by the different methods was given and it was concluded that, with the possible exception of the " bump " technique with wing-fuselage combinations agreement was good, in spite of large differences in Reynolds number.

THE CLOSING SESSION

When the last lecture had been given the delegates adjourned once more to the Dome for the closing ceremony, which was presided over by Major Halford, supported by Admiral Richardson and representatives of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society.

MAJOR HALFORD:—He had two more messages to read; the first was from His Majesty The King in response to a message from the delegates which had been sent off when the Conference began, and the second was from the American Ambassador to Great Britain:

To HIS MAJESTY THE KING, Balmoral, Aberdeen, Scotland.

On behalf of the Council and all members of the Royal Aeronautical Society, of which you are its patron, we submit to you our humble duty on the occasion of the holding of the Third Anglo-American Aeronautical Conference in Brighton, with the Institute of the Aeronautical Sciences of the United States of America.

I recall that these two scientific and aeronautical engineering societies convened the first Anglo-American Aeronautical Conference in London in 1947 and the second in New York in 1949. These two Societies include in their membership the leading aeronautical scientists, research workers and designers of both countries. They meet to discuss outstanding aeronautical problems whose solution will prove invaluable in the future peaceful progress of aviation, and to provide that deep understanding of each other's technical problems without which close co-operation is not possible.

F. B. HALFORD, President, Royal Aeronautical Society.

From: Balmoral Castle.

To: President, Royal Aeronautical Society.

The King sincerely thanks the Council and members of the Royal Aeronautical Society for their kind and loyal message sent on the occasion of the Third Anglo-American Aeronautical Conference which His Majesty as their Patron warmly appreciates.

PRIVATE SECRETARY.

From HIS EXCELLENCY THE UNITED STATES AMBASSADOR IN LONDON.

I am happy to send my greetings to the Third Anglo-American Aeronautical Conference and to express my confidence that this meeting has continued the distinguished accomplishments which the preceding conferences have established. I believe it can be said that in no other field have our two countries more effectively proved their remarkable capacities for scientific co-operation and progress. And in no other field that I can conceive of have the fruits of this mutual enterprise been more beneficially and consistently apparent. Such advantages accrue with double impact; for they are most valuable and desirable in a peaceful world and should it ever be necessary will prove to be vital in a world at war.

Please convey my warm good wishes to all members of the Conference and my regrets that I could not be present.

WALTER S. GIFFORD.

In the past four days 20 lectures had been given, covering a wide technical field in aviation; both civilised and uncivilised! The lectures had been very well attended, although the discussions would have been even more valuable had they been a little more bilingual.

He congratulated and thanked the staff of the Society for their work in making the Conference a success, coupled with the name of Captain Pritchard.

He looked forward to the Fourth Anglo-American Conference in 1953, when—if they extrapolated the appropriate curve—there should be, for the first time, an attendance of at least one thousand people.

REAR ADMIRAL RICHARDSON:—He felt that the first half of the second cycle of the Anglo-American Conferences had been a great success. Planning from the beginning was good; it made the most of the experience gained in the other two conferences. Captain Pritchard's visit to the United States in January had done a good deal to prepare for the excellent arrangements which had been made. The type of papers and the illustrations were exceedingly well selected and they contained a great deal of important material. Most had been extremely well delivered, in fact, all had. He congratulated his fellow-countrymen on the way in which they had delivered their papers. He was particularly proud of them.

There was a noticeable lack of discussion on the part of the Americans. He had kept score at the ten sessions which he attended; 73 British delegates spoke and 21 Americans, including Dr. Ted Wright six times. That was an average of 1.5 Americans per meeting, if Dr. Wright were discounted (but he never could be!). There were various reasons for the lack of discussion by Americans; they only had about 100 delegates and he did not suppose there had been that many in any one session. There were about 400 British delegates. The Americans included a smaller proportion of what might be called the "working level" of people, who knew in detail the latest opinion on the subject of the papers. That reminded him of something that Mr. Grumman had said. He had asked him who was present from his company and Mr. Grumman had said no one except himself, and had added, "The others have to work."

Certainly the silence of the American delegates was not from lack of interest. They were intensely interested in all that went on and they envied the British delegates the training they had, and in some cases the background that they had, to enter into that sort of thing. Probably they had also had more chance to read the papers in advance. The Americans had received theirs the day they arrived.

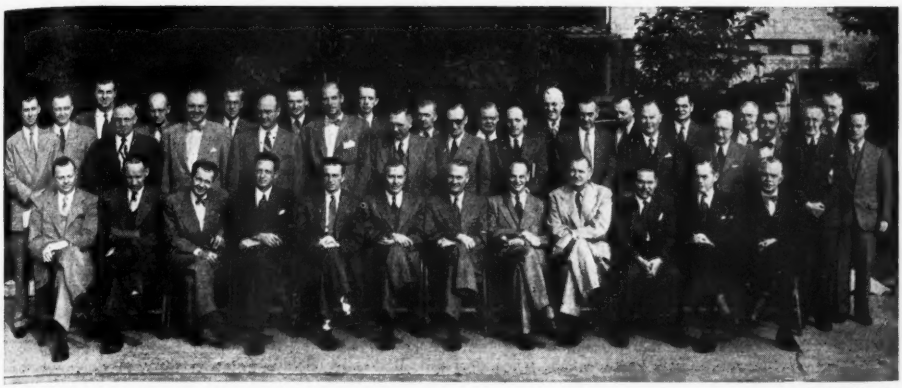
The next time he hoped they would do three things: furnish copies of the papers well in advance. That called for faster finishing of the job by the authors. Secondly, send more "working level" people to the Conference; that would be easier for the Americans next time. Thirdly, the authors should make a pact with some of their friends to discuss things and to be ready to do so when the time arrived.

Then there were the informal gatherings between the sessions and at other times. The schedule had been cleverly planned to allow time for that and he felt that everyone had extended his total of friends. The comradeship had been a delightful occurrence.

He had to express his admiration for the logic, philosophy and humour of the British delegates and the people who discussed the papers. They seemed to inject a fund of sound philosophy and some humorous cynicism into it all which he had found a great treat.

They had completed those meetings with strengthened feelings of comradeship and they looked forward to the following week's programme.

They looked forward to seeing everyone again in 1953.



de Havilland

American Delegates at The de Havilland Aircraft Co. Ltd.:—(*Seated, left to right*): E. G. Stout, J. D. Redding, Dr. S. J. Zand, W. A. Shrader, R. R. Dexter, S. Paul Johnston, Admiral Richardson, A. E. Raymond, G. Starbird, R. W. Young, Captain J. J. Ide, Dr. E. R. Sharp. (*Standing, left to right*): G. Phillips, F. W. Fink, G. Brady, J. W. Larsen, G. S. Schairer, F. N. Piasecki, H. Woodward, D. R. Shoults, L. S. Rockefeller, J. W. Myers, W. N. Enyart, Dr. H. L. Dryden, P. R. Bassett, L. R. Grumman, Elmer Sperry, Professor N. J. Hoff, F. P. Lauden, J. Stack, L. A. Wood, E. E. Aldrin, P. B. Taylor, J. Crowley, R. J. Woods, N. Burgess, Dr. E. S. Moult, Lt.-Col. L. D. Ely and R. T. Leadbetter.

THE SECOND WEEK

Although not offically part of the Conference, the date of the Wilbur Wright Memorial Lecture had been arranged to coincide with the time when so many Americans were expected to be in London. The lecture, given by Mr. A. E. Raymond (reported in the October 1951 JOURNAL) was attended by several hundred members of the Society, guests, and Conference delegates and their ladies, most of whom, with many others, went on to the reception held at the Society's home, 4 Hamilton Place.

On Wednesday 12th September, delegates to the Conference were the guests of His Majesty's Government at a reception held at Lancaster House, where they were received by Mr. G. R. Strauss, Minister of Supply.

Following the Conference at Brighton a number of visits had been arranged for the American delegates to firms in the Aircraft Industry, Government establishments and to the S.B.A.C. Display. The following is a list of those visits:

Monday 10th September—The College of Aeronautics; The National Physical Laboratory.

Tuesday 11th September—Anglo-Iranian Oil Co. Ltd.; de Havilland Aircraft Co. Ltd.

Wednesday 12th September—The Society of British Aircraft Constructors' Display, Farnborough.

Thursday 13th September—The Bristol Aeroplane Co. Ltd.; Hawker Aircraft Co. Ltd.

Friday 14th September—Rolls-Royce Ltd.; Vickers-Armstrongs Ltd.

The Society is greatly indebted to the Government, the Aircraft Industry, the Society of British Aircraft Constructors and to all those who, by their willing co-operation and assistance contributed to, and made possible, the success of the Third Anglo-American Aeronautical Conference.

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The Seventh British Commonwealth and Empire Lecture

AIR TRANSPORT IN NEW ZEALAND AND THE SOUTH PACIFIC

by

SIR LEONARD ISITT, K.B.E.

The Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," by Air Vice-Marshal Sir Leonard Isitt, K.B.E., R.N.Z.A.F. (Ret'd.), was read before the Royal Aeronautical Society by Mr. T. A. Barrow, J.P., on 4th October 1951 at the Institution of Civil Engineers, Great George Street, London, S.W.1. Major G. P. Bulman, C.B.E., F.R.Ae.S., Past-President, presided.

MAJOR BULMAN:—He was sure that they would all regret that Major Halford was unable to be present; immediately after the reception following the Wilbur Wright Lecture, he had had an operation, and although it was successful he had to undergo a course of treatment which would keep him out of circulation for another five or six weeks. They hoped that at the end of that time they would enjoy his presence and leadership for the rest of his year of office.

It was for him a very real pleasure, despite the sad reason, to take the chair for the second time at a British Commonwealth and Empire Lecture. These lectures—instituted originally by Mr. G. H. Dowty—were given alternately by a distinguished representative from the Mother Country and from the Dominions and Empire. They had had one from Australia, two from Canada and now New Zealand.

Air Vice Marshal Sir Leonard Isitt had had a distinguished career in the Air Force, first with the R.F.C. and Royal Air Force and then with the Royal New Zealand Air Force, and had now turned his attention to civil aviation. He was Chairman of New Zealand National Airways Corporation and of Tasman Empire Airways and a Director of British Commonwealth Pacific Airlines. Unfortunately, because of the recent election in New Zealand he had found it impossible at the last minute to be with them. They had just received a cable from him: "Regret inability to be with you in England today. Please accept apology and best wishes."

In place of Sir Leonard Isitt they had the pleasure and privilege of welcoming Mr. T. A. Barrow, J.P., who would read Sir Leonard's paper. Mr. Barrow had been Secretary of the New Zealand Air Board since 1937. He was also Vice-Chairman of Tasman Empire Airways.

COMMONWEALTH air communications are vital to the economic progress of the Commonwealth and Empire in peace and if possible of even greater importance in war.

Perhaps the Antipodes is not the best place in which to appraise commercial aviation, because of remoteness from the aviation industry and from the dense network of air routes in Europe and on the American continent. On the other hand the Antipodes are more dependent on air transport, both domestic and overseas, because of:

(*a*) the lack, or lower standard, of other transport;

(*b*) the longer distances involved;

(*c*) the difficult terrain; and

(*d*) geographical isolation, necessitating special efforts to maintain speedy communications with the centres of industry, trade and world power.

STATISTICAL DATA ON NEW ZEALAND CIVIL AVIATION

New Zealand is a small country with a population of two millions. In the following paragraphs an attempt is made to show comparatively its progress in air transport.

Many will recall that a statement was issued by I.C.A.O. early in 1951 about the development of world civil aviation (excluding the U.S.S.R. and China) from 1937 to 1950. Working on the same basis information

TABLE I

Year	*Passenger kilometres performed (thousands)*	*Cargo ton kilometres performed (thousands)*	*Notes*
1935	369	2.9	
1936	3,760	2.9	
1937	7,415	5.2	Domestic traffic only
1938	10,426	11.9	
1939	10,859	19.8	
1940	9,064	26.6	Domestic traffic including non-revenue operations
1941	12,389	43.8	
1942	12,116	50.5	
1943	14,425	53.9	Domestic and International traffic including non-revenue operations
1944	25,811	105.5	
1945	29,290	120.3	
1946	45,697	200.0	
1947	91,779	813.1	
1948	126,253	1678.4	
1949	126,153	2061.0	
1950	156,926	2873.0	

From I.C.A.O. Statistical Summary No. 10, with Addenda Sheets 1-33.

has been extracted on the development of New Zealand aviation over the years 1935 to 1950 (Table I).

Table II shows a comparison, for the World and for New Zealand, of percentage increases over periods of years.

Table III deals with civil aviation statistics in Commonwealth countries and in the U.S.A.

Table IV shows Aircraft Kilometres, Passenger Kilometres and Cargo/ton Kilometres performed both per head of population and per area square mile. It will be seen that among the countries quoted New Zealand takes third place per head after Australia and the United Kingdom, and third place per square mile after the United Kingdom and the United States of America.

Table V shows figures for domestic scheduled services in Commonwealth countries and the United States of America. These figures have been extracted from published national statistics; the figures for the United Kingdom are provisional; the figures for the U.S.A. include trunk, feeder and territorial lines.

Again it has been attempted to show New Zealand's place among Commonwealth countries and the United States of America by relating aircraft-miles and passenger-miles flown and revenue-passengers carried, to both the population and the square mileage of the country's area. As can be seen from Table VI, New Zealand ranks second after Australia in the number of passengers carried per head and second after the United States in revenue passenger miles flown per square mile. New Zealand ranks third in aircraft miles flown per head (after Australia and the U.S.A.), in aircraft miles flown and revenue passengers carried per square mile (after the U.S.A. and the United Kingdom), and fourth (after Australia, the U.S.A. and Canada) in revenue passenger miles flown per head of population.

NEW ZEALAND'S AVIATION POLICY

No organisation, be it a Department of State, a State-sponsored Corporation, or private enterprise, can operate in a manner that is not in accord with the policy of its government. Consider the policy during the years of development and the factors conducing to those decisions.

The policy of the New Zealand Government towards the development of air transport was influenced by many factors. Not least among these was the view of the early colonists, which was given expression in the legislation of the Liberal Administra-

TABLE II

Period	*Passenger kilometres performed*		*Cargo ton kilometres performed*	
	World per cent	*N.Z. per cent*	*World per cent*	*N.Z. per cent*
1937/1950	+1743	+2016	N/A	+55,150
1947/1950	+ 38	+ 71	+155	+ 253

tion in the latter part of the nineteenth and early part of the twentieth centuries, that public utilities should be undertaken by the Crown or local Government. Moreover, New Zealand has always taken cognizance of practices adopted by the United Kingdom and there a single corporation existed for the operation of the air transport services. A third factor was the desire for co-operation in external air transport services. The Commonwealth

TABLE III

Country	*Year ended*	*Aircraft kilometres performed*	*Passenger kilometres performed*	*Cargo ton kilometres performed*	*Population*	*Area square miles*
				(*thousands*)		
Australia	30. 9.50	72,359	1,215,185	38,757	8,600	2,975
Canada	30.11.50	46,583	840,496	8,935	13,500	3,845
Ceylon	31. 7.50	1,540	12,153	104	6,500	25
India	31.12.50	30,404	375,582	18,157	360,000	1,220
NEW ZEALAND	31.12.50	*9,822	156,926	2,873	2,000	103
South Africa	30. 6.50	11,623	200,627	2,617	11,500	473
United Kingdom	31.12.50	73,397	1,099,650	31,344	50,500	93
U.S.A.	31.12.50	758,996	16,444,829	414,943	154,000	2,977

* Error in Addendum Sheet No. 19; total of monthly figures for 1950 is 9,822,000.

From I.C.A.O. Statistical Summary No. 10, with Addenda Sheets.

TABLE IV

Country	*Aircraft kilometres performed*		*Passenger kilometres performed*		*Cargo ton kilometres performed*	
	per head of population	*per area square mile*	*per head of population*	*per area square mile*	*per head of population*	*per area square mile*
Australia	8.5	24.3	142.9	408.4	4.6	13.0
Canada	3.5	12.1	62.2	218.5	0.7	2.3
Ceylon	0.2	61.6	1.9	487.0	0.02	4.2
India	0.08	24.9	1.0	307.7	0.05	14.9
NEW ZEALAND	4.91	95.3	78.4	1516.2	1.4	27.8
South Africa	1.0	24.6	17.4	424.2	0.2	5.5
United Kingdom	1.5	789.2	21.8	11824.2	0.6	337.0
U.S.A.	4.92	255.0	106.8	5524.0	2.7	139.4

TABLE V

Country	*Year ended*	*Revenue Aircraft miles flown*	*Revenue Passenger miles flown*	*Revenue Passengers carried*	*Population*	*Area square miles*
				(*thousands*)		
Australia	30. 9.50	38,596	621,155	1,549	8,600	2,975
Canada	30.11.50	24,894	432,231	1,025	13,500	3,845
NEW ZEALAND	31. 3.51	4,369	59,745	238	2,000	103
United Kingdom	28. 2.51	6,946	80,387	484	50,500	93
U.S.A.	31.12.50	364,075	8,002,198	17,340	154,000	2,977

TABLE VI

Country	*Revenue Aircraft miles flown*		*Revenue Passenger miles flown*		*Revenue Passengers carried*	
	per head of population	*per area square mile*	*per head of population*	*per area square mile*	*per head of population*	*per area square mile*
Australia	4.5	13.0	73.0	208.8	0.2	0.5
Canada	1.8	6.5	32.0	112.4	0.07	0.3
NEW ZEALAND	2.2	42.2	29.9	577.2	0.119	2.3
United Kingdom	0.1	74.7	1.6	864.4	0.01	5.2
U.S.A.	2.4	122.3	52.0	268.8	0.113	5.8

family—a family of equals—owes a great deal of its strength to co-operation.

To deal first with the internal air services. Some initial development was undertaken by private enterprise, but the Labour Government never entirely accepted this method of development. They made no early change on assuming the Government in 1935, mainly, perhaps, because, like so many other people in the world, they had not appreciated the potential of air transport and the dynamic influence that it would have upon transport economy and in relations between men. The outbreak of the Second World War in 1939 postponed any major change in the method of operation of the internal air services, and it was not until 1945 that the Government gave notice of their decision to establish a Corporation, wholly owned by the Crown, which would be responsible for the operation of all the internal air services. It is not appropriate to deal in detail here with every development of the Corporation but it is worth emphasising that the Act establishing the Corporation imposed a special responsibility on it to provide not only the profitable trunk services, but also, feeder and development services.

In deciding in 1945 that the commercial air services within New Zealand should be operated by a public corporation, the Government were influenced also by economic considerations. During the 1939-45 War, air power had demonstrated its capacity not only as an important weapon of war but also as a great service to mankind. In a country like New Zealand, which has many difficulties of terrain and a high average income, it was to be expected that there would be a strong demand for the provision of air services. On many of the secondary routes the services would not be profitable, certainly not in the initial stages, but the trunk line routes would be very profitable. To meet the needs of air transport development and to ensure that the profits on the trunk line services were used to assist the development of services on the secondary and feeder routes, the National Airways Corporation was formed.

The Corporation had its teething troubles, including the problems inevitably associated with the operation of so many types of aircraft, acquired under the purchase arrangements made by the Crown with the private companies.

Although New Zealand had always shown great interest in the operation of a trans-Pacific service by air—an interest demonstrated by negotiations and discussions with other governments, including the Government of the United States in the years prior to the outbreak of the 1939-45 War—attention was focused initially upon the provision of services in the area of the South-West Pacific. First attention was given to the link between Australia and New Zealand, which was essential not only to meet local traffic needs but to complete the air link between New Zealand and and the United Kingdom. Reference has been made to the influence that Commonwealth considerations had on the policies of the Government. When the time was ripe to establish Tasman Empire Airways it was decided that the Company should be established jointly by the United Kingdom, Australia and New Zealand. This expressed in practical form the strong desire of New Zealand to have a close link, not only with Australia but with the United Kingdom also—a link that it wishes to maintain in every way possible. Although there was grave risk in 1939, following the outbreak of war, that the aircraft could not be released for the operation of this service, it was a matter of great satisfaction to the New Zealand Government at the time, following personal discussions by Mr. Fraser with Mr. Anthony Eden and Mr. Menzies, that the service was established. When all the regular passenger vessels were withdrawn from the New Zealand-Australia trade to meet the needs of war, the Tasman service demonstrated its vital importance to both Australia and New Zealand.

The war period saw also the development of air transport services between New Zealand, Fiji and the Islands of the South Pacific. There had always been a substantial community of interest between the countries of this area, but adequate and speedier communications were demanded by the needs of war. The Royal New Zealand Air Force pioneered the transport services within the area and these were taken over by New Zealand National Airways Corporation in 1947. The link between New Zealand and Fiji is potentially a profitable one, but the services to Tonga, Cook Islands and Western Samoa are not profitable at present, and it may well be some time before they can be made so. The reasons for this are obvious:

the low level of average income of the people, the sparse population, the great distances to be flown over water, and the unsuitability and high cost of operating the aircraft which have been employed in this service. The service was continued by New Zealand National Airways Corporation using Dakota aircraft—the only aircraft available to them—and recently Tasman Empire Airways have operated a Solent service between Auckland and Suva, the chief town of Fiji. It has been decided to withdraw the Dakota operation completely and the service will be operated by Tasman Empire Airways, which it is hoped will run on to Tahiti in French Oceania. There is not only community of interest between New Zealand and French Oceania (of which the peoples of both countries became aware during the war years) but also opportunity for tourist development to the mutual advantage of the two peoples.

The service to Tonga was instituted by the New Zealand Government, notwithstanding that it involved direct losses for New Zealand. This was undertaken as an acknowledgment of the special Commonwealth association between the Kingdom of Tonga and New Zealand and the desire of the Government of New Zealand to assist in developing British community of interest and influence in the South-West Pacific.

There are certain clearly defined elements in the policy that led to the air transport development in the South Pacific. All New Zealand Governments have valued highly the Commonwealth associations and placed importance on action which will develop and nourish this association. The spirit which inspires the Commonwealth is, and must be, co-operation; that is reflected in its aviation policies, particularly in the special association with the United Kingdom and Australia in the operation of Tasman Empire Airways and the trans-Pacific services operated by British Commonwealth Pacific Airlines. Not only is there this insistence upon co-operation but on orderly and economic development of international air transport. While New Zealand has conceded Fifth Freedom rights to the trans-Pacific operators on the direct route to New Zealand—and this affects traffic between Fiji and New Zealand—she has nevertheless insisted on protecting the regional air services. New Zealand has a feeling that, in negotiating the Bermuda formula, insufficient weight was given to the position and needs of the regional air services, particularly those that must be operated over long distances with limited traffic potential. This is the position in the South Pacific. It is felt that it would be a short-sighted policy to sacrifice or prejudice the interests of regional air services, which have great importance in their own right, for those of long-distance operation. In the event of any emergency great importance would attach to the regional air services and, in the effort to strike a balance between the needs of long-route trunk services and the regional services, more emphasis must be placed in future upon the needs of the latter.

COMMONWEALTH CO-OPERATION IN THE PACIFIC

Just fifteen years ago, in September 1936, the Governments of the United Kingdom, Australia and New Zealand agreed upon the establishment of a joint company for the operation of the trans-Tasman air service between Australia and New Zealand. This air service forms the last link in the long chain of air transport services between Great Britain and New Zealand.

According to this agreement, the operating company would be registered in New Zealand, licensed by the Governments of New Zealand and Australia to operate the service, and would be granted contracts for the carriage of mail by the United Kingdom, Australia and New Zealand. The first survey of the route was undertaken by Imperial Airways in 1937.

Early in 1938 the negotiations that were to lead to the formation of Tasman Empire Airways Limited were resumed between the three governments, and the first aircraft, a Short S-30 Empire class flying boat—the Aotearoa—was test-flown in England in June 1939. Shortly after her arrival in New Zealand war was declared.

Under a more detailed agreement concluded in April 1940 the three governments again agreed on the setting up of the operating company established for the purpose of operating a regular civil air transport service for the carriage of passengers, freight, and mails, across the Tasman Sea between New Zealand and Australia. The company was formed by Imperial Airways Ltd. for the United Kingdom, Qantas Empire Airways Ltd. for Australia, and by Union Airways of N.Z. Ltd. for New Zealand; and also by four other members approved by the three

governments, who took one share each. The company was registered in New Zealand in April 1940 under the name of "Tasman Empire Airways Ltd."

Under the terms of a further agreement made in December 1941 between the three governments and Tasman Empire Airways Ltd., the company undertook to maintain and operate regular and efficient air transport services. This agreement also provided for the establishment of a "Tasman Air Commission," which would consist of one representative of each government and take decisions by majority vote. The Commission's office would be located in New Zealand. To this Commission could be delegated by the governments the rights, powers, and duties under the Governments-Company agreement.

This particular instance of Commonwealth co-operation for the purpose of setting up an operating company has been dealt with in greater detail because, to the author's knowledge, it is the first instance of airline operation by a joint stock company, the shares in which are held by governments.

The next noteworthy event in co-operation between two Commonwealth countries in civil aviation matters was the conclusion of the Australian-New Zealand agreement of 21st January 1944, the so-called "Canberra Pact." This agreement between the two governments deals in clauses 17 to 23 with civil aviation matters as follows:

"17. The two Governments agree that the regulation of all air transport services should be subject to the terms of a convention that will supersede the convention relating to the Regulation of Aerial Navigation.

"18. The two Governments declare that the air services using the international air trunk routes should be operated by an international air transport authority.

"19. The two Governments support the principles that

(*a*) full control of the international air trunk routes and the ownership of all aircraft and ancillary equipment should be vested in the international air transport authority; and

(*b*) the international air trunk routes should themselves be specified in the international agreement referred to in the next succeeding clause.

"20. The two Governments agree that the creation of the international air transport authority should be effected by an international agreement.

"21. Within the framework of the system set up under any such international agreement the two Governments support:

(*a*) the right of each country to conduct all air transport services within its own national jurisdiction, including its own contiguous territories, subject only to agreed international requirements regarding safety, facilities, landing and transit rights for international services, and exchange of mails;

(*b*) the right of Australia and New Zealand to utilise to the fullest extent their productive capacity in respect of aircraft and raw materials for the production of aircraft; and

(*c*) the right of Australia and New Zealand to use a fair proportion of their own personnel, agencies and materials in operating and maintaining international air trunk routes.

"22. In the event of failure to obtain a satisfactory international agreement to establish and govern the use of international air trunk routes, the two Governments will support a system of air trunk routes controlled and operated by Governments of the British Commonwealth of Nations under government ownership.

"23. The two Governments will act jointly in support of the above-mentioned principles with respect to civil aviation, and each will inform the other of its existing interests and commitments as a basis of advancing the policy herein agreed upon."

It will be recalled that the first concrete proposals for international ownership and operation of international civil air transport services was made by the French delegation to the Disarmament Conference of the League of Nations in 1932. According to this proposal, all international civil air transport services were to be entrusted to continental, inter-continental or inter-colonial organisations operating under the auspices of the League of Nations. However, neither the Disarmament Committee nor the League of Nations succeeded in creating an international air transport organisation.

In the same year in which the Canberra Pact was concluded, the Chicago Conference on International Civil Aviation took place.

Immediately before this international conference, Commonwealth countries gathered at Montreal for informal discussions on civil aviation matters, and re-assembled in London after the Chicago Conference. The outcome of these discussions was the establishment of the Commonwealth Air Transport Council as a consultative body dealing with matters affecting civil aviation of common interest to Commonwealth countries.

Under the permanent chairmanship of the Minister in charge of Civil Aviation in the United Kingdom, and with a capable secretariat provided by the United Kingdom Ministry of Civil Aviation, the Commonwealth Air Transport Council serves as a useful medium for exchange of views and information between Commonwealth countries on civil air transport matters. The Council keeps under review the progress and development of Commonwealth civil air communications and considers and advises on such civil aviation matters as the Commonwealth governments may agree to refer to the Council.

Under the Commonwealth Air Transport Council there is established a Committee for Air Navigation and Ground Organisation, which functions as an organisation for the dissemination of technical material of common interest to the various member countries of the Commonwealth.

In New Zealand great benefit is derived from the activities of the Commonwealth Air Transport Council and from the meetings held under its auspices.

Following the Canberra Pact and Chicago Conference, to which the idea of international ownership was submitted by the Australian and New Zealand authorities, the United Kingdom, Australian and New Zealand Governments agreed at the Commonwealth Conference held at Montreal, that the principle of airline operation by government-owned operators should be put into effect on the trans-Pacific route. They decided that a joint operating organisation comprising interests of the United Kingdom, Australia and New Zealand should operate the route from Australia and New Zealand to Canada, operating in parallel with a Canadian airline.

Recommendations for the establishment of a trans-Pacific joint operating airline were again adopted at a meeting of the Commonwealth Air Transport Council held in London in 1945 and at a Civil Aviation Conference held in Wellington early in 1946. The latter conference decided upon the establishment of a tri-partite organisation, to be known as British Commonwealth Pacific Airlines, to be established for the purpose of operating the trans-Pacific air services between New Zealand and North America and between Australia and North America. This company should be registered in Australia, and the capital was subscribed—20 per cent. by the Government of the United Kingdom, 50 per cent. by the Government of Australia and 30 per cent. by the Government of New Zealand. Under this agreement British Commonwealth Pacific Airlines Ltd. was registered in Sydney (N.S.W.) in June 1946. Thus began the second venture in inter-Commonwealth aviation enterprise.

> In speaking at the International Civil Aviation Conference in Chicago in 1944, the Honourable D. G. Sullivan, the leader of the New Zealand delegation, said, "We fully appreciate the importance of the subject which we are about to discuss. We know that the peace and prosperity of New Zealand depend in the most intimate degree upon the peace and prosperity of the whole world. We know how greatly our common well-being and our future collaboration will depend upon this great question of International Air Transport, and how important it is that this means of communication and co-operation, this growing triumph of science over distance and misunderstanding, should take that shape that is best calculated to lead to the common welfare of man."

The Wellington Civil Aviation Conference (1946) also agreed upon the establishment of the South Pacific Air Transport Council, a regional organisation under the aegis of the Commonwealth Air Transport Council. The establishment of such regional organisations under the Commonwealth Air Transport Council was recommended by this Council at a meeting held in London in July 1945. A similar regional organisation has been established in South Africa.

The original functions of the South Pacific Air Transport Council were to advise member governments on matters of policy concerning Tasman Empire Airways Ltd. and British Commonwealth Pacific Airlines Ltd., to promote the development of regional services in the South Pacific, to consider all technical and financial questions arising relating to the airfields in United Kingdom territories for which the Australian and New Zealand Governments have undertaken to

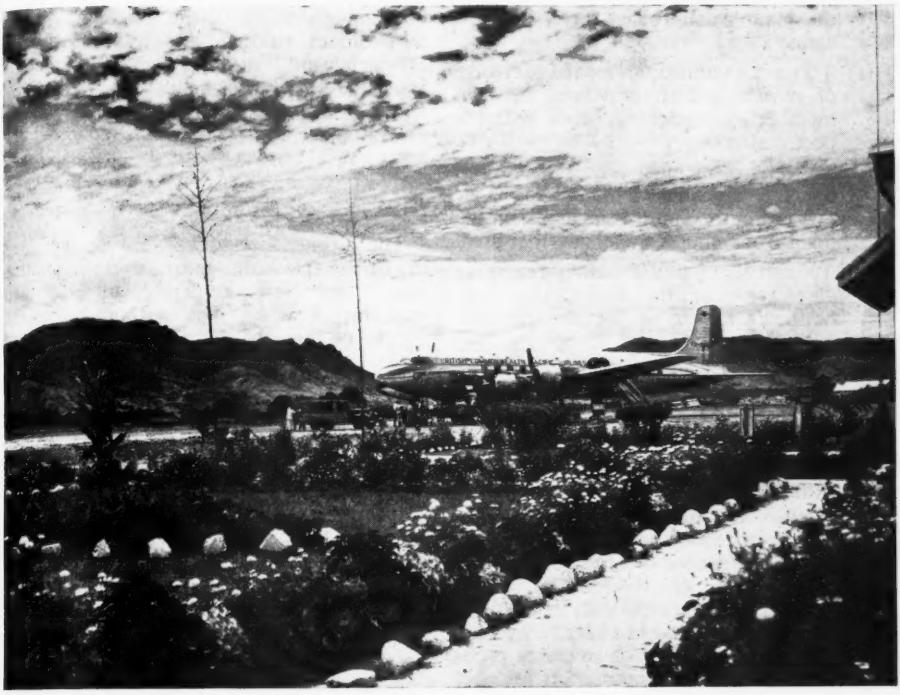
arrange assistance, and to advise on any civil aviation matters referred to it by member governments. Membership of the Council was open to the United Kingdom, Australia, Canada, Fiji and the Western Pacific High Commission and New Zealand, but Canada initially declined the opportunity of participation on the grounds that she had no specific interests or activities in the South Pacific. However, with the introduction of a Canadian air service over the main Pacific trunk route between Vancouver and Sydney, Canada became concerned in the provision of facilities, procedures and planning in the region and she applied for, and was granted, full membership of the Council in December 1948.

Special committees under the South Pacific Air Transport Council were appointed to deal with matters of policy affecting British Commonwealth Pacific Airlines Ltd. and Tasman Empire Airways Ltd. (replacing the Tasman Air Commission).

The Civil Aviation Conference held in Wellington in March 1946 also considered the utilisation of the former military aerodrome at Nadi, in the Colony of Fiji, as an airport for civil flying. In 1939 a small airfield was constructed at Nadi by the New Zealand Public Works Department for use by a R.N.Z.A.F. reconnaissance squadron. After the outbreak of war in the Pacific this airfield was considerably extended by the R.N.Z.A.F. and by civilian construction units, and finally was taken over by the United States Army Air Corps. The Wellington conference realised the importance of Fiji as a stepping-stone on Trans-Pacific flights between New Zealand and Australia on the one hand and North America on the other, and also on South Pacific regional flights. It was also realised that the colonial territories of Fiji and of the High Commission for the Western Pacific were in themselves unable to provide and man the technical facilities required for air services operating within the South Pacific region, or passing through this region. In addition, the conference considered that the British Colonies could not meet the whole cost of providing airports and facilities in their territories and that the Dominion Governments interested in the Empire trunk routes, together with the United Kingdom Government, should make financial contributions to the provision and maintenance of airports and facilities in Colonial territories. The conference accepted the principle that the ownership of ground facilities should be vested in the government controlling the territories in which the equipment is situated, but that New Zealand and Australia should arrange, in their respective areas, the technical services and staff required for the whole area on the understanding that appropriate contributions towards the cost of the services should be made by the United Kingdom in respect of stations in their territory. New Zealand undertook to provide technical assistance in United Kingdom territories in the South Pacific to the east of the meridian of 170°E. and Australia in respect of United Kingdom territories West of that line.

The first meeting of the properly established South Pacific Air Transport Council was held in Canberra in December 1946. This meeting again agreed that Nadi airport should be developed as an international airport by the New Zealand authorities and that the cost of operation and maintenance of the airport, together with such capital work as may be approved, should be met by the New Zealand Government and charged to a pool account for subsequent adjustment by the governments concerned, in accordance with their decisions as to financial contributions. The basis of contributions by governments has varied. The original arrangement provided for a 50 per cent. contribution by the United Kingdom and a contribution of 25 per cent. each by Australia and New Zealand. At a later stage all three governments agreed to contribute one-third each, but when (in 1948) Canada joined the South Pacific Air Transport Council it was agreed that each of the four governments should contribute a quarter to maintenance expenditure, while the United Kingdom, Australia and New Zealand would share capital expenditure at the rate of one-third each.

Under a New Zealand airport manager and with staff from the New Zealand civil service, the necessary aeradio, air traffic control, meteorological, works and administrative services have been established by New Zealand at Nadi since November 1946 in order to provide the requirements and facilities for a regular international airport. For the fairly large New Zealand community in the Colony of Fiji special arrangements had to be made to provide for adequate housing of single and married personnel, for medical care, schooling and recreation. As



Flowers, sunshine, clouds and a fine aeroplane—all harmonious in the charming Fijian scene at Nadi (or Nandi) Airport on the Island of Viti Levu, Fiji.

a good example of effective and satisfactory Commonwealth co-operation, the airport doctor has been appointed by the Fiji Government and, with the help of a New Zealand nurse and of a dispensary staffed and equipped by the Fiji Government, looks after the health of the airport staff. The Fiji Government also provides mosquito control services. A New Zealand school teacher is responsible for the education of the children of members of the airport staff and a kindergarten mistress looks after the children of pre-school age. A New Zealand welfare officer has been appointed with the object of organising sports and other suitable entertainment for the fairly large proportion of young staff members.

Further meetings of the South Pacific Air Transport Council took place in 1947, 1948 and 1950. Following the 1948 meeting, when Canada decided to join the Council, it became necessary to modify the constitution of the Council and to assign all matters concerning British Commonwealth Pacific Airlines Ltd. and Tasman Empire Airways Ltd. (in which companies Canada was not a shareholder) to special and separate organisations called the British Commonwealth Pacific Airlines Policy Committee and Tasman Empire Airways Ltd. Policy Committee. The present functions of the Council are as follows:

(*a*) To keep under review and to promote the progress and development of Commonwealth civil air communications in the South Pacific and on the main trunk air routes traversing that area.

(*b*) To advise member governments regarding the development, installation, operation and maintenance of such technical and other facilities, including aerodromes, as are considered by the Council to be necessary in their respective territories for the safe and efficient operation of existing or contemplated Air Services in the South Pacific or on

the main trunk routes traversing that area.

(*c*) To serve as a medium for the exchange of views and information between member governments on civil air transport matters.

(*d*) To advise member governments on matters affecting Commonwealth air services in the South Pacific and on the main trunk routes traversing that area.

(*e*) To carry out any function regarding air services in the Pacific that may be delegated to it by the member governments.

(*f*) To consider and advise on such civil aviation matters as may be referred to the Council by any member government.

(*g*) To maintain liaison and to co-operate with the Commonwealth Air Transport Council and on air transport matters with other Commonwealth and international organisations interested in the development of the Pacific. The Council, to a large extent, is a policy-forming body, and in order to assist it in the consideration of technical problems, two standing committees were set up—the Committee for Air Navigation and Ground Organisation (S.P. CANGO) and the Committee of Meteorologists (S.P. COMET). It is customary for these Committees to convene immediately prior to a Council meeting and to report to the Council.

Permanent Chairman of the Council is the Minister for Civil Aviation in Australia, and the Australian Department of Civil Aviation provides a permanent secretariat.

The Council has performed valuable work in the planning of facilities and services for international and regional air services in the South-West Pacific, including the establishment of Nadi airport in Fiji.

From the foregoing the strength of Commonwealth co-operation in planning and policy will be seen. Have we therefore quite departed from the principle of international control and ownership so often voiced? In the matter of international ownership, it can be assumed that the difficulties are such that no one has really tried to solve them. In control and mutual co-operation there is the International Air Transport Association, that exceptional example of the best principles of international co-operation which, under the brilliant leadership of the Director-General, Sir William Hildred, and a succession of Presidents and Working Committees from the Industry, has done so much to solve international difficulties and problems with a united front, and which looks like providing a permanent answer.

AIRLINE OPERATION

The airline operators—New Zealand and the British Commonwealth—operating within and from New Zealand will now be examined briefly. The author is on the boards of three of these companies. These three airlines cover all main air transport operations within New Zealand and between New Zealand and Australia. They also operate services between New Zealand and Fiji and the Pacific Islands to the east of Fiji; between Australia and North America; and between New Zealand and North America; and the economic operation of these airlines has been the chief concern of the boards of the companies, and it is proposed to review their operations separately.

New Zealand internal services

It is necessary to know something of New Zealand. The Maori some six hundred years ago named the country "Aotearoa," which means "The Long White Cloud," and Abel Tasman, when he first discovered the Islands in 1642, described them as "a high bold land." The noticeable degree of cloud still persists and the country can be described as steep and rugged. New Zealand consists of two large, and several small, islands. It lies in the South Pacific Ocean, some 1,300 miles to the east of Australia, with South America some 6,000 miles distant to the east and the Arctic Continent 1,600 miles to the south. The area is 103,735 square miles and it is a high mountainous country lying between the southern latitudes 34° and 48°. Only the two main islands where the population is chiefly distributed will be considered. These two islands are in all approximatelly 1,000 miles in length and have an average width of 100 miles. Running the full length of both islands there is a mountain chain which is seldom below 4,000 feet, with many peaks of over 8,000 feet, and with the highest mountain a little over 12,000 feet. The country is generally hilly, less than 25 per cent. being below 650 feet and a considerable proportion is still in its native state of grass and bush,

the high country area being rock, shale and snow.

Ground communications—road, rail and coastal shipping—must be considered good, but there are topographical features that load the balance in favour of the air. This is particularly true of the division of the two Islands by the turbulent Cook Strait, which necessitates a sea crossing of some 50 miles, or travel by air. Railways travel at considerably slower speeds than in Europe or America, because of their narrow gauge and the mountainous country.

The country is largely pastoral, sheep-farming and dairying being the main industries, but during the past ten years many secondary industries have been developed. Of the population, 60 per cent. is urban and 40 per cent. rural. The urban population is settled chiefly in four main areas—Auckland (309,000), Wellington, the capital (193,000), Christchurch (172,000) and Dunedin (91,000).

When the Government decided to nationalise the internal air services in 1945 there were three main companies operating: Union Airways of N.Z. Ltd., providing services between the main centres of population; Cook Strait Airways Ltd., which held a licence to operate services across Cook Strait; Air Travel Ltd., a company operating air services on the West Coast of the South Island (an area usually described as "wild and woolly") and whose activities were individualistic and similar to the work of the bush pilots of Canada. Surface transport had suffered through the war years, and to supplement this the Royal New Zealand Air Force transport squadrons were engaged in public transport of passengers and also in operating an air freight service on behalf of the New Zealand Railways between the rail terminals of the North and South Islands.

It is not practicable to give individual credit to the various companies and individuals for the good work they have done in pioneering commercial aviation in New Zealand. The decision to nationalise was based on policy and not on dissatisfaction with the services then being operated.

The Government's decision to nationalise was implemented by an Act bringing into being a Corporation ". . . for the purpose of establishing and operating national air transport services to meet the needs of the public of New Zealand and for the purpose of fostering and encouraging the use of air transport within New Zealand and between New Zealand and other countries." Certainly a comprehensive and constructive mandate.

It is not proposed to argue a case for nationalisation; a case for it can be based on the following grounds:

(*i*) Aviation is an industry in which the very high cost of equipment and small returns for the capital invested make it unattractive for the private investor, especially in small countries.

(*ii*) It becomes more practicable to use profits on main lines to absorb losses on lateral routes.

(*iii*) Development in a national rather than in a commercial sense becomes feasible.

(*iv*) Cut-throat competition is eliminated.

(*v*) There is a better prospect of paying for aerodromes and other ancillary services.

The major demerit of nationalisation of air transport seems to be slowness in arriving at final decisions on commercial and other propositions.

Prior to 1939 there was little regular airline operation in New Zealand. Aerodromes were small, route facilities were limited, and operations were based on contact flying. During the 1939-45 War there was a big expansion of military flying; the Air Force strength expanded from 3,000 to 45,000, and many aerodromes were constructed. Unfortunately they were not sited with a view to post-war commercial use—at that stage speed of construction was the governing factor. These war years saw the introduction of traffic control and navigational aids. It was against this background in 1946 that the Corporation began operations. Some aerodromes passed to civil use, while others were combined for dual use by the Military and Civil. Aircraft available in New Zealand (taken over from the companies absorbed) were put into service; fourteen DC-3's and Lodestars were taken over from the Air Force and converted for the carriage of passengers and freight.

The policy of the Corporation was to expand services to meet the traffic demand, and to operate such additional services as were warranted to meet the needs of isolated areas. Development was rapid and the aim was to operate a timetable to enable a passenger to move between any two towns in New Zealand on the same day. Aerodromes and route facilities were improved, but it was

not until 1950-51 that night flying became possible. Within New Zealand an unduplicated route mileage of 2,947 is operated on a frequency to meet normal demand with a daily average of 15,500 miles.

The services have been described as austere by one well-known British authority. There are not the usual amenities; neither hostess nor steward is carried, nor are meals served during trips of two hours or less. Hostesses are on the ground at main airports, and light refreshments are available in the airport buildings on a cash basis. But the services operate on time with a high factor of regularity and markedly increasing popularity.

From the point of view of financial return, the four years' operations cannot claim to have been successful, but the steady growth of passenger and freight traffic and the financial result of the immediate past year's operations indicate a satisfactory position.

NEW ZEALAND NATIONAL AIRWAYS CORPORATION — INTERNAL SCHEDULED SERVICES

New Zealand National Airways Corporation (N.Z.N.A.C.) completed its first full year of operation in March 1948. A statistical summary of operations is given in Table VII. The following figures show the traffic increases:

	1948	1951
Passenger-miles	33 millions	59 millions
Freight ton-miles	478 thousands	1618 thousands
Mail ton-miles	97 thousands	125 thousands

Operating with a capital of £1,200,000, N.Z.N.A.C. has made an accumulated loss of £600,000; it has established obsolescence reserves of £500,000. The year ended March 1951 showed an operational profit of £8,500.

In face of the high average load, it may be considered surprising that the corporation has failed in the past to operate economically, but costs have been inordinately high, due largely to limited aerodromes, which has necessitated the operation of various and uneconomical types of aircraft, in many cases with a limited weight, making a break-even load factor on the existing low fare impossible to achieve.

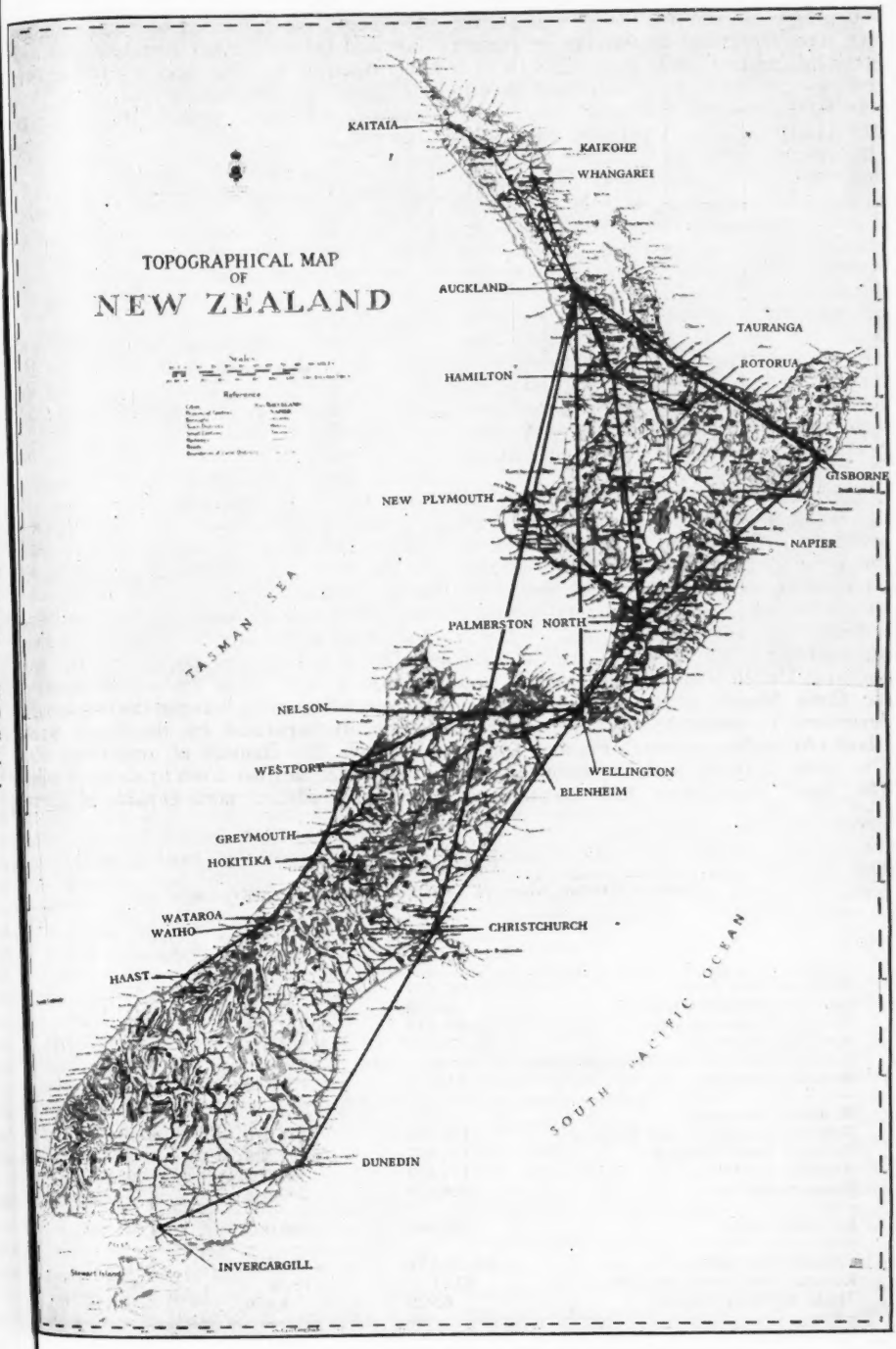
The improved financial position is due to many factors, but chiefly to improved aerodromes and route facilities, more centralised maintenance, elimination of some of the aircraft types, lifting of weight restrictions, introduction of night operations, better utilisation.

During the year 1950-51 the seating capacity of the DC-3 has been increased to 24 and an increase has been granted in the all-up weight from 24,200 lb. to 26,900 lb. Gradually the Lodestars have been replaced.

TABLE VII

NEW ZEALAND NATIONAL AIRWAYS CORPORATION: SCHEDULED SERVICES

Year ended 31st March	1948	1949	1950	1951
Revenue miles flown	3,116,124	4,298,922	4,591,224	4,369,308
Revenue passengers carried	147,253	174,836	204,707	238,405
Revenue passenger-miles	33,808,603	44,323,199	49,478,365	59,744,623
Available seat-miles	40,681,905	55,690,283	69,441,927	75,055,387
Revenue passenger load factor per cent	83.1	79.59	71.25	79.60
Revenue mail-tons	254.3	335.9	389.9	409.2
Revenue freight-tons	372.9	675.5	969.8	2243.0
REVENUE TON-MILES				
Passengers and baggage	2,759,417	3,688,674	4,127,372	5,008,737
Excess baggage	34,397	48,395	69,602	85,448
Freight	91,569	194,449	281,573	573,369
Mail	97,310	108,580	121,251	128,923
TOTAL	2,982,693	4,040,098	4,599,798	5,796,477
Revenue load factor per cent	70.85	67.48	63.59	71.75
Capacity ton-miles	4,209,913	5,986,727	7,233,993	8,078,730
TOTAL ANNUAL REVENUE HOURS	26,669	31,386	35,249	34,066



New Zealand internal services.

One type of aircraft is the ideal and is the aim, but aerodrome limitations at present make this an impossible goal. The DC-3 is proving very satisfactory, and it will have to satisfy the Corporation for a few more years. The ideal would be a twin-engined 25/30-passenger aircraft, with a speed of 370 m.p.h., and range of 700 miles, to operate on a maximum runway length of 4,000 feet and with de-icing equipment. If aerodrome runways improve it may be possible to go to a larger aircraft. There is also the need for a smaller aircraft, a 15/20-passenger machine, capable of operating from 2,700 foot strips at sea level, and with a range of 400 miles. This aircraft does appear to be in view, but a further adjustment of fares and rates will probably be needed to get the break-even load factor desirable. The development and operation of helicopters is being watched carefully.

There are two other operations with which the National Airways Corporation has been associated. One is the Regional service in the South Pacific, which has been operated on a weekly or fortnightly basis, serves the widely dispersed and small communities, and provides an administrative link between Metropolitan New Zealand and Western Samoa (a United Nations Trust territory) and the Cook Islands group (a New Zealand dependency), operating through Norfolk Island (Australian territory), Fiji and Tonga. The route distance is 3,820 statute miles. The small populations and considerable distances have precluded economical operation and the service has been operated on a subsidised basis. The other is a freight ferry operated in conjunction with the New Zealand Railways between the two main Islands.

Inter-island air freight service

New Zealand has watched with great interest the development of air freighting all over the world, and in particular the operation of Bristol Freighters across the English Channel.

Sixty-eight per cent. of the population of New Zealand lives in the North Island and 32 per cent in the South Island. Of the 20,246 factories registered in New Zealand on 31st March 1950, 66 per cent. are located in the North Island and 34 per cent. in the South Island. Out of about 34 millions of sheep, the North Island has 57 per cent. and the South Island 43 per cent. Of about five millions of cattle, the North Island carries 86 per cent. and the South Island 14 per cent. About 69 per cent. of the persons engaged in farming reside in the North Island and 31 per cent. in the South Island. Because of this distribution of population and production a fairly large amount of freight is permanently moving between the two Islands, which are separated by the Cook Strait. Although this channel of sometimes very rough water narrows down to about 15 miles, the nearest efficient ports capable of accom-

TABLE VIII

Tasman Empire Airways Limited: scheduled services

	April 1 1948 *to March* 31 1949	*April* 1 1949 *to March* 31 1950	*April* 1 1950 *to March* 31 1951
Revenue miles flown	1,187,839	1,183,644	1,329,208
Revenue passengers carried	24,520	22,579	31,434
Revenue passenger-miles	32,905,839	30,301,016	41,941,132
Available seat-miles	36,578,894	36,204,476	49,736,302
Revenue passenger load factor per cent	89.96	83.69	84.33
Revenue mail-tons	155	178	209
Revenue ton-miles			
Revenue passengers and baggage	3,126,511	2,849,019	3,967,124
Revenue excess baggage	34,477	25,828	40,063
Revenue cargo	173,419	190,509	309,938
Revenue mail	208,625	242,646	277,463
Revenue total	3,543,032	3,308,002	4,594,588
Capacity ton-miles	4,288,951	4,103,346	5,743,577
Revenue load factor per cent	82.61	80.62	79.99
Total revenue hours	6,925	6,659	7,116

An airport within the city. Mechanics Bay air base, Auckland, New Zealand. Administrative and operating base of Tasman Empire Airways Limited.

modating overseas vessels (Wellington and Lyttelton) are about 200 miles apart. The nearest airports suitable for freight-carrying aircraft (Paraparaumu and Woodbourne) are only 72 miles apart, and this distance could be reduced to 50 miles with the development of the airport at Wellington. An air freight service across Cook Strait, operated with Dakota aircraft, was organised by the New Zealand Railways Department, in conjunction with the R.N.Z.A.F., in February 1947. In June 1947 operation of the service was handed over to the N.Z. National Airways Corporation, who continued to operate this freight service with DC-3 aircraft. Some idea of the growth of the Cook Strait air freight service during the past years may be gained from the following figures.

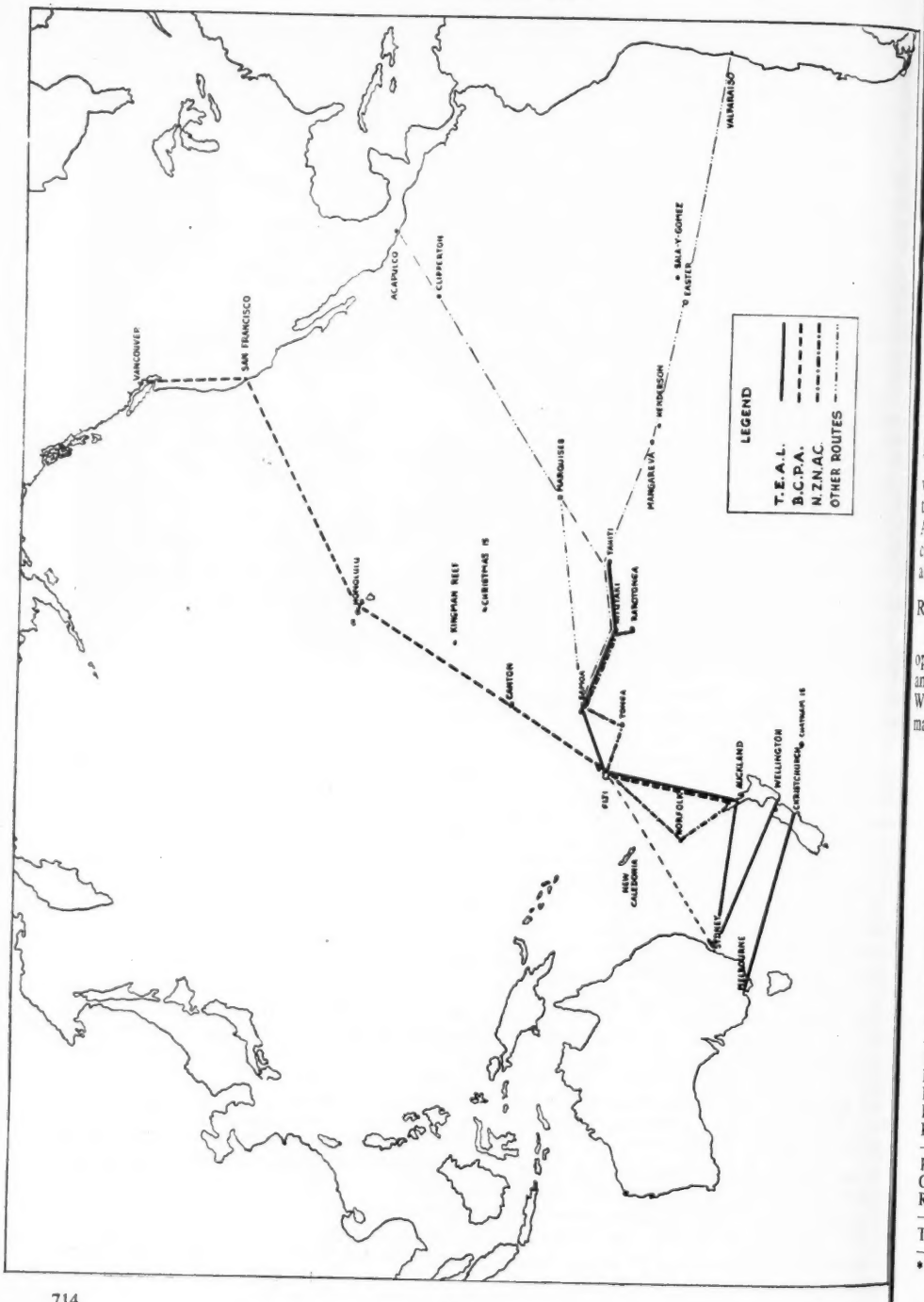
In the first complete year of operations, the year ended 31st March 1948, the number of trips flown was 1,786, mileage covered was 138,266, and freight carried was 13,081,232 lb., involving a total of 1,114 flying hours. For the year ended 31st March 1951, these figures had increased to 4,927 trips, 320,714 miles and 31,293,293 lb. of freight, flown in 2,778 hours. The service is currently being operated by Straits Air Freight Express Ltd., the successful tenderers to the New Zealand Railways for this air link. They are using Bristol 170 Freighters.

TASMAN EMPIRE AIRWAYS LTD.

In September 1936 the Governments of the United Kingdom, Australia and New Zealand agreed upon the establishment of a joint company for the operation of a trans-Tasman air service.

Tasman Empire Airways Ltd. was incorporated in New Zealand on 26th April 1940, and began operations on 30th April 1940, when a flight was made from Auckland to Sydney by the Short S-30 flying boat "Aotearoa."

The equipment of the company originally comprised two Short S-30 flying boats. With the end of the 1939-45 War the company


VANCOUVER
SAN FRANCISCO
ACAPULCO
CLIPPERTON
VALPARAISO
SALA-Y-GOMEE
EASTER
HENDERSON
MANGAREVA
MARQUISES
TAHITI
PENRHYN
RAROTONGA
NIUE
TONGA
FIJI
NORFOLK
AUCKLAND
WELLINGTON
CHRISTCHURCH
NEW CALEDONIA
SYDNEY
BRISBANE
HONOLULU
KINGMAN REEF
CHRISTMAS IS
CANTON
LEGEND
T.E.A.L.
B.C.P.A.
N.Z.N.A.C.
OTHER ROUTES

acquired on hire three Tasman-class flying boats, each capable of carrying 30 passengers each way between Australia and New Zealand, and schedules were extended to provide up to nine return services each week.

In 1948 the two original Tasman Empire-class flying boats were withdrawn from service and an additional Tasman-class boat was obtained on hire, bringing the total of the company's fleet to four aircraft.

On 22nd February 1948, the Tasman-class Sandringham aircraft were grounded by the company as the result of engine cooling troubles and for four months the services were operated by the company with charter aircraft on the Australian register.

Authority for the purchase of four Solent flying boats, each capable of carrying 45 passengers, was obtained in August 1947. The first scheduled flight by a Solent aircraft was made on 13th November 1949, when the "Ararangi" left Auckland for Sydney. An additional Solent has now been purchased, bringing the company's fleet to five aircraft.

Route Pattern

For over ten years the company has operated regular services between Australia and New Zealand, and during the 1939-45 War the company's aircraft were used on many occasions for special flights and long-range reconnaissance. A statistical summary of operations is given in Table VIII.

Financial Summary

Tasman Empire Airways Ltd. completed its first operational year in March 1941 and has shown the following traffic increases:

	1941	1951
Passenger-miles	2 millions	42 millions
Freight ton-miles	11 thousands	350 thousands
Mail ton-miles	46 thousands	277 thousands

Operating with a capital of £1,500,000, this company, in its 11 years of operation, has made a gross profit of £140,990; it was equipped with new aircraft in 1949, and has established an obsolescence reserve of £175,000. An operational profit of £13,500 was made in the year ended March 1951.

During 1950-1951, the services have been extended to provide four to five return services a week between Wellington and Sydney; six to seven return services a week between Auckland and Sydney; and a weekly return service between Christchurch and Melbourne. This latter link has been introduced only recently and, in the first place, will be operated under charter by Skymasters of Qantas Empire Airways.

There appears to be a limit above which traffic is unlikely to increase for some years. The total number of passengers who cross the Tasman Sea by sea and air does not exceed

TABLE IX

British Commonwealth Pacific Airlines Limited: scheduled services

	**April* 25 1948 *to* *June* 30 1948	*July* 1 1948 *to* *June* 30 1949	*July* 1 1949 *to* *March* 31 1950	*April* 1 1950 *to* *March* 31 1951
Revenue miles flown	311,055	1,934,841	1.839,044	2,455,866
Revenue passengers carried	1,024	7,079	8,934	13,976
Revenue passenger miles	5,379,100	33,633,306	35,539,641	61,540,767
Available seat-miles	11,780,836	67,948,208	76,769,082	98,316,938
Revenue passenger load factor per cent	45.66	49.5	46.29	62.6
Revenue mail-tons	6.8	39.9	35.5	54.4
REVENUE TON-MILES				
Revenue passenger baggage	480,029	3,121,780	3,312,314	5,763,814
Revenue excess baggage	5,464	32,639	31,220	58,456
Revenue freight	29,907	314,556	326,191	484,075
Revenue mail	42,531	264,285	239,021	352,412
REVENUE TOTAL	557,931	3,733,260	3,908.746	6,658,757
Capacity ton-miles	1,141,449	8,365,999	8.223.082	12,322,892
Revenue load factor per cent	48.88	44.62	47.53	54.04
TOTAL REVENUE HOURS	1,546	8,546	7,285	9,718

* From 25th April 1947 to 25th April 1948 the service was operated by Australian National Airways on charter.

70,000 a year, of which the air is moving approximately 40 per cent. Surface competition is provided by two fast and comfortable ships, which make the crossing in three days and provide a weekly service. It is unlikely that a great percentage of the total traffic will be gained until the air fare becomes more competitive with the sea fare. The only prospect of reducing air fare appears to be the introduction of high density seating and more efficient aircraft.

The steady growth of traffic—passengers, freight and mail—has demonstrated the essential nature of the services and the financial results of the company over the years of its operation have been satisfactory.

The importance to New Zealand of the Tasman air link has been demonstrated both in war and in peace, and for many months at a time it has provided the only regular link with Australia in particular, and with the world in general.

BRITISH COMMONWEALTH PACIFIC AIRLINES LTD.

British Commonwealth Pacific Airlines Ltd. (B.C.P.A.) was established by the Governments of Australia, New Zealand and the United Kingdom in 1946 to operate an air service between Sydney and North America and between Auckland and North America, on a route Fiji/Canton Island/Honolulu/San Francisco, with the right to extend beyond San Francisco, U.S.A., to Vancouver, Canada.

The service was started in April 1947 by Australian National Airways on a 12 months' charter to the new company, using DC-4 Skymasters. From April 1948 the B.C.P.A. operated the route with its own staff and aircraft, first with DC-4s and later with DC-6s.

Three return services a fortnight are operated between Sydney and North America, and one return service a week between Auckland and North America—a route distance of approximately 7,000 statute miles. The growth of traffic has been steady and the financial results for the year ended 31st March 1951 showed a profit—after meeting all interest and taxation—of £(A)41,000.

From a global aspect the Pacific air link is of vital importance both as a trade channel and as a strategic air route in time of war.

A statistical summary of operations is given in Table IX.

FINANCIAL SUMMARY

B.C.P.A. completed its first year of operations in 1948 and has shown the following traffic increases:

	1949	1951
Passenger-miles	33.6 millions	61.5 millions
Freight ton-miles	314.5 thousands	484.0 thousands
Mail ton-miles	264.5 thousands	352.0 thousands

AIR TRANSPORT IN EMERGENCY

The value of commercial air services to meet emergency was fully demonstrated during the recent waterfront strike, which tied up shipping—both coastal and inter-Commonwealth in the Pacific—and slowed up overseas vessels.

While the air services could not handle the bulk cargo, they did handle passengers and urgent freight and kept the wheels of industry turning. As a local newspaper commented:—

> "Wherever people wanted to go, they could go by air; wherever people wanted goods to go, they could go by aircraft . . . it (aviation) now has a major role in the economic life of New Zealand."

Some comparative figures, for three months of the strike, compared with figures for the same period the year before, are of interest:—

	April/June 1950	*April/June* 1951
Internal Services—		
Passenger-miles	17.2 millions	24.7 millions
Freight ton-miles	112 thousands	847.7 thousands
Mails total uplifted	120 tons	338 tons
Inter-Island Railway Freight—		
Freight ton-miles	259 thousands	700 thousands
Trans-Tasman—		
Passenger-miles	8.9 millions	16.5 millions
Freight ton-miles	65.2 thousands	448.9 thousands
Mails total uplifted	43.4 tons	61.5 tons

In its four years of operation the company has made an accumulated loss of £580,000; it was re-equipped with DC-6 aircraft in 1948 and has established an obsolescence reserve of £560,000. A profit of £41,000 was made for the year ended March 1951.

The lessons confirmed by the operation of these three airlines are that the main factors that influence passengers are:

(*a*) Type of equipment,

(*b*) Frequency and regularity,

(*c*) Passenger service and amenities,

and the two biggest factors in keeping down costs are:

(*i*) Maximum aircraft and crew utilisation,

(*ii*) Centralised maintenance.

It is not suggested that the airlines have gone as far as they would wish in any of these matters; they realise that proper planning is essential to efficient airline operation. In each of these three airlines the position has been steadily improving from year to year and from quarter to quarter; with existing types of aircraft it is still possible to improve economy of operation, although there does come a time when more cannot be done with existing types.

The airlines have operated up to the present only with government assistance, and very substantial government assistance. The landing grounds, the air route organisation, the meteorological services—these have all been provided by governments at little cost to the operators who, if they were required to bear even a limited portion of these costs, would have to increase their charges to an impossible degree or go out of business.

New Zealand internal passenger revenue for 1950 did not exceed £1,500,000, while the New Zealand Government spent £1,427,000 on aviation administration and facilities in New Zealand territory.

Has government support and assistance been towards the orderly development of the Industry?

The author believes that the answer is that the control and support, in general, have been to the benefit of the Industry and of air power—irksome as the resulting restrictions may be at times. Each country has its own problems and deals with them in its own way, but all have found it necessary to encourage and support Air Transport, both internal and overseas.

That great democracy, the United States of America, has stated a policy which, even if it does not lead to greater economy of operation, is a policy that is well expressed and the only possible policy that can be pursued by democracy in these times. Briefly, it is governed by the over-riding consideration that "we may protect ourselves against both aggression from abroad and bankruptcy at home." It is well stated that the air power of the United States should be maintained at such effectiveness as to be able in all circumstances to control the air spaces of the United States, its possessions, territories, bases and occupied lands wheresoever, and be able to retaliate in greater degree for any attacks launched by air, or otherwise, against the peace and security of the United States or those free Allied governments with which it is joined for mutual defence. And it is recognised that air power is indivisable, and every pilot, air crew member, aircraft worker, wherever and however employed, contributes directly to the Air Power of the nations.

PROSPECTIVE WORLD ROUTES

From time to time a good deal has been heard about a Southern Pacific route from South America to New Zealand and Australia.

In April 1951, Captain P. G. Taylor—that great pioneer and long distance pilot—flew a Catalina from Sydney, Australia, to Quintero, near Valparaiso, South America, and returned, by way of Fiji, Papeete and Easter Island. Captain Taylor reported that the establishment of an air service along that route was feasible and recommended that it should be operated by landplanes as it was possible to construct a landing area on Easter Island but that there was insufficient protected water to provide an alighting area for flying boats. It would be necessary to construct aerodromes at Papeete and at Easter Island and it is most doubtful if there is traffic offering to warrant even a monthly service.

The South Pacific Air Transport Council reported adversely in 1948 on the development of this route, as it was considered that there was little traffic offering or that could be generated. However uncertain the circumstances, this might prove an important strategic air route and the thanks of the

Empire are due to Captain Taylor for demonstrating its possibilities.

A more feasible and strategic route to Europe from the Antipodes is the route pioneered, also by Captain Taylor, in a Catalina in 1945 from Acapulco in Mexico, by way of Clipperton Island, Bora Bora, Fiji and Sydney. It would serve a greater proportion of the world's population than the more southern route. This route would also have considerable strategic interest should the free movement of aircraft be denied on the present Pacific route. Its chief operational difficulty is the long stage of 3,000 nautical miles between Clipperton and Bora Bora. The late Air Commodore Brackley was interested in this route as a possibility for the Princess flying boat.

Considerable expenditure would be necessary before either route could be operated regularly by any type of aircraft that is foreseen today and in the opinion of the author the expenditure necessary to develop these routes could not be justified on a commercial basis.

There are other prospective commercial routes in the Pacific. The isolation of island groups and in some cases of individual islands within a group, creates the need, but the people are neither numerous nor wealthy and the long distances and small communities will retard the development of these services.

REPLACEMENT AIRCRAFT FOR OVERSEAS ROUTES

The objective of every airline is to achieve a profit from its operations and in order to do this the types, or type, of aircraft operated is probably the chief factor. The high cost of modern transport aircraft makes it essential that the most suitable type for the route to be operated be selected. It cannot be selected purely on present conditions of traffic, but must be sufficiently flexible for adaption to luxury travel or high density seating. Speed in most cases is of first consideration, but the aircraft must also provide maximum flexibility to meet changing traffic and operating conditions. It should have high profit potential and be designed to provide for technical development during its life so that it may remain competitive and profit-earning.

It is not proposed to consider in detail the question of aircraft replacement. If operators are to meet competition and operate economically, they must operate the most suitable

SURVEY OF ALIGHTING AREAS AND AERODROMES IN THE PACIFIC

The history of this development is noteworthy for the close collaboration between New Zealand and United States interests.

In 1935 a New Zealand civil engineer was sent by cruiser to begin a survey of a New Zealand-Hawaii air route. In 1938 the present Director of Civil Aviation in New Zealand was sent in H.M.S. *Leander*, with a Walrus aircraft at his disposal, to continue this work. He was instrumental in photographing and ground surveying the Line Islands, Palmyra, Phoenix, Samoa, Tokelau, Fiji, and Tonga groups.

In March 1939 the following stage had been reached:—

(*a*) The lagoon at Christmas Island was ready to accept the Short S-26 type flying-boat;

(*b*) Four different routes between Hawaii and New Zealand were recommended: Hawaii/Canton/Fiji/Auckland; Hawaii/Fanning/Western Samoa/Auckland; Hawaii/Christmas Island/Western Samoa/Auckland; Hawaii/Christmas Island/Tongatabu/Auckland—all flying boat routes;

(*c*) Construction of air bases was in hand at Nausori (Fiji) and Fua'amotu (Tonga).

The New Zealand survey of Canton Island was completed by the United States.

In 1940, six weeks before Pearl Harbour, New Zealand completed a survey of the maze of lagoons at Christmas Island, which is some 40 x 15 miles in extent. Land and flying boat bases on the Island were built from the New Zealand surveys. Subsequently the air bases in Western Samoa were built by the United States from New Zealand surveys.

After Pearl Harbour a yacht, used by Pan American World Airways as a houseboat at Noumea, was taken over for survey work and New Zealand and United States parties visited Tongareva, Aitutaki, and Bora Bora, where landing strips and radio ranges were subsequently established. In 1943 the New Zealand Ministry of Works constructed the air base at Rarotonga. Towards the end of the 1939-45 War a New Zealand expedition surveyed islands along the route to South America, east of the French possessions, penetrating as far as the Chilian island of Sal y Gomez, midway between Eastern Island and Valparaiso.

THE ENGLAND—CHRISTCHURCH (N.Z.) AIR RACE 1953

A matter of great interest to the Industry is the England/New Zealand Air Race which is to be held in 1953 under the Regulations of the Fédération Aéronautique Internationale and the competition rules of the Royal Aero Club of the United Kingdom.

The Race is being organised by the Royal Aero Club and a strong New Zealand Air Race Council.

There are two sections: Speed, and a Transport Handicap. There is to be only one control point, which will give the greatest possible freedom to entrants to exploit both the range and speed of their aircraft.

A great deal of interest has already been expressed in the United Kingdom and it is hoped that the 1953 Race will challenge the MacRobertson Race of 1934 as a milestone in the progress of Aviation.

aircraft available for their particular route. Flying boats might be mentioned here.

The author has not written them off yet. T.E.A.L. are still operating flying boats and, if suitable replacement flying boats were available, would continue to operate them as the sea alighting areas on their routes are more adjacent to the cities and centres served than are the available international land aerodromes. To mention the most outstanding cases:

	Alighting area miles	*Aerodrome miles*
Auckland	2 ...	22
Wellington	1½ ...	100
Sydney	2 ...	6
Suva, Fiji	3 ...	150
Papeete, Tahiti ...	3 ...	150—involving a sea crossing

Again, in the cost of the preparation of alighting areas against the cost of aerodrome construction, the advantage lies with the flying boat. Throughout the whole Pacific area the majority of islands provide areas which, at little cost, can be made suitable for the operation of flying boats. The provision of facilities for the extension of the T.E.A.L. flying boat service from Suva, Fiji, to Tahiti, by way of Tonga, Samoa, Aitutaki, is estimated not to exceed £180,000.

T.E.A.L. have recently extended their trans-Tasman service to include Wellington/Sydney and Christchurch/Melbourne services. The cost of providing all facilities in Wellington, including pontoon, moorings, and domestic and technical buildings, was less than £100,000. The estimated cost of providing an aerodrome at Wellington was £3,000,000, and the cost of extending and sealing the runways at the Christchurch aerodrome for the trans-Tasman traffic was £400,000.

However, there are many excellent aircraft in production and on the draughting board, and it is the operator's problem to select the most suitable type to his particular needs, and in view of production problems and the time factor, this must be at least two years before he wants delivery.

In spite of the distance from the manufacturers, New Zealand is kept well informed. British constructors are well represented in New Zealand and sales representatives of the major constructors make frequent visits. The Society of British Aircraft Constructors also sees that the country is kept up to date on the progress and achievements of British aircraft.

Today we are on the eve of tremendous changes and developments with the early introduction of turbo-propeller and turbo-jet aircraft, which must revolutionise the whole aspect of air transport. There are, however, major problems—particularly for small airlines—in this question of re-equipment.

It is significant to note that of new aircraft types which will be available for long-range operation during the next two or three years, only one is fitted with engines that have been operated in civil transport aircraft on commercial routes. The fact that the new power units are not as yet in general use makes assessment of their maintenance and reliability difficult at this stage. The development of these engines has been rapid, but long rigid periods of test have been completed and it may be assumed that they are sound and reliable and by no means untried.

There is a marked difference in the performance characteristics of aircraft fitted with the three types of engines: turbo-jet, turbo-propeller and piston-propeller. The turbo-jet, while offering the highest speeds, has inferior take-off and initial rate of climb,

Kongotai, which is to be developed as an aerodrome to serve Wellington, the capital city of New Zealand and, beyond, Evans Bay, which has been developed as a flying boat terminal.

compared with aircraft using airscrew propulsion, and fuel consumption is high in comparison with the turbo-propeller on a fuel-per-hour per lb. of thrust basis.

The turbo-propeller is more efficient in take off, at lower altitudes and in low-speed flying. Therefore it is a much more flexible aircraft but it has not the advantages of the high speed attainable by the turbo-jet.

The difference in fuel consumption between piston-powered aircraft and turbo-propeller aircraft is not wide, and in view of the extra speed obtainable with the turbo-propeller unit, the fuel consumption, range and flexibility may be taken as comparable.

Air traffic problems may become restrictive on the use of jets at aerodromes with high traffic density, but this should not be insurmountable and will not be a major factor in the Pacific.

Maintenance

It can be, and has been, assumed that maintenance costs will be no higher than on present types of aircraft and at least a reduction in man-hours on overhaul and maintenance can be hoped for, although replacement parts may increase in number and cost.

To sum up, the turbo-jet offers the highest speed and the highest annual earning capacity, but lacks flexibility, which may impose limitations on its operational pattern. It is particularly suitable for long-range operation.

The turbo-propeller offers advantages in speed over orthodox piston-engined aircraft at round about the same cost per ton-mile, although somewhat restricted on short- and long-range routes.

It can be accepted that future aircraft will be developed around both the new types of engine. At the same time, for the smaller, short-range aircraft the piston engine still seems to have the promise of a long life, particularly where speed is not of first consideration or of paramount importance.

The airlines' first problem is to select the aircraft best suited to their routes. Many factors must be considered operationally: aerodromes, length of route, and winds in transit are of first importance; economical operation, maintenance cost, and payload; and finally, passenger appeal.

If an operator can be content with speeds in the order of 360 to 390 m.p.h., the turbo-propeller aircraft will answer his purpose for the next seven or eight years. On the other hand, on long routes where speed is of first importance, there is no doubt of the advantage conferred by the turbo-jet aircraft.

The other problems are economic and do not relate directly to choice of aircraft.

The two overseas companies with which the author has the privilege to be associated are small companies operating limited routes. One, B.C.P.A., is in keen competition with other airlines, and in 1950 carried a total of approximately 14,000 passengers. Mail and freight do not bulk largely. The passenger load factor was 62.6 per cent. and the revenue load factor was 54.04 per cent.; the revenue hours per annum being 9,718.

The other company, T.E.A.L., has a virtual air transport monopoly on its limited route between Australia and New Zealand, but keen surface competition. In 1950, the company carried approximately 30,000 passengers, the passenger load factor being 83.3 per cent., the revenue load factor 80 per cent., and the revenue hours per annum were 7,392.

Both these companies must re-equip shortly if they are to maintain their share of the traffic essential to their economic well-being. Suitable aircraft for their respective routes is a matter of selection. The first problem is the cost of these new aircraft and the financing of the new fleets.

Manufacturers claim that with greater speed more work is done in a given time. To put it briefly, they say, "Revenue is based on mileage and costs are based on hourly rates; therefore, you can't go wrong, you double your speed and halve your costs." But an examination of the problem on the information the author has indicates that the ton-mile or passenger-seat-mile cost will not be very greatly improved in the face of rising costs. This problem can be, and will be, met; it is just a question of the best method.

The second problem is capacity. If the speed of the equipment is doubled, it is equivalent to doubling the size of the aircraft, and unless traffic can be increased, equilibrium can only be maintained between required aircraft utilisation and load factor by reducing frequency, with its adverse effect on traffic.

It can be claimed that increased speed and convenience will increase traffic and that the shorter journey time will enable the introduction of higher density seating and allow lower fares, and thus tap a new stratum of air traveller, which will ensure maximum utilisation, satisfactory load factors, and sound and economic operation. But this view requires some optimism and one cannot be too optimistic where the large sums of money foreseen are concerned.

The author is forced to the conclusion that the average airline is not in a financial position to replace its fleet without recapitalisation; that the smaller airlines will not be able to attain full utilisation of their aircraft and continue to provide competitive frequency. Is the answer that the smaller airlines are to be abandoned or that some of the routes are to be rationalised by merging these airlines?

Looked at from the angle of national need and aspiration, this would not be the answer. The author also believes that the small organisation operating a limited route, is more efficient and offers better personal service to its customers than the big, world-wide organisation, and desirable as mergers may appear on economic grounds, the argument of national need, national aspiration and passenger appeal must prevail.

Would it be possible to establish a Commonwealth aircraft-holding corporation responsible for the provision, overhaul and maintenance of a common aircraft type? The operating airline would be responsible for its own management, route operation, sales, passenger, and freight handling, and purchase from the holding company the aircraft hours it required for its operations. Such a proposition would involve so much faith in the other fellow and give-and-take in the early negotiations as to preclude it from a successful launching. But the author believes that some such scheme is necessary and will probably narrow down to inter-airline agreements for the common use of aircraft on a contractual basis.

It is hoped that the paper has given some appreciation of New Zealand's problems and how it has met, and is meeting, them. The importance of Commercial Aviation is such

that no nation of any standing can afford to disregard it. It is the most important factor in communications today and, therefore, in international relationship, in overseas trade, and as part of the nation's air power it is indispensable.

It is our duty as members of the Industry to see that air transport plays its full part in the promotion of peace by a better understanding between peoples of the world, and should the free democracies fail to curb the forces of aggression, to be ready and capable of fully supporting the armed forces in the struggle for freedom and self-determination.

ACKOWLEDGMENTS

The author acknowledges his indebtedness in the preparation of the paper to Dr. P. P. Heller, Economic Investigation Officer, New Zealand Civil Aviation Branch of the Air Department, and to Whites Aviation Ltd. for the photographs used to illustrate the paper.

MR. PETER MASEFIELD, F.R.Ae.S., proposed a vote of thanks to the author and the reader of the paper:—It was his pleasant duty to propose what was, perhaps, a rather unusual proposition, a joint vote of thanks to both the originator of the lecture—Sir Leonard Isitt—and to the reader—Mr. Tom Barrow. He found himself in a slightly cleft stick; one prong being the substance of Mr. T. A. Barrow with them that evening, and the other, since he must be in the sunshine at that moment, the shadow of Sir Leonard Isitt.

As one who had enjoyed both the hospitality and the aviation of Sir Leonard and Mr. Barrow in New Zealand, it was a privilege to have the opportunity of paying a tribute to the work done in New Zealand on air transport.

Noticing the progress of air transport between North and South Island, one wished that there was a Cook Strait between England and Scotland, not only to keep out the wild Scots, but also to provide that economy of air transport which occurred when the railways were interrupted in that way.

As the lecturer had shown, in New Zealand aviation might be "under," but it was certainly not "down." One peculiar thing was that, in that part of the world, they had achieved so much in inverted flight, without realising it.

As one who had a somewhat unfashionable leaning towards flying boats he was delighted to note how well the British Short Solent flying boats had done on the Tasman route, and it was a great pleasure to see Mr. Roberts of Tasmans, as well as Mr. Barrow, present on that occasion. They all regretted very much that Sir Leonard Isitt could not be with them; their loss in that respect had been a gain in another way in that it had brought Mr.Barrow to talk to them.

Mr. Barrow was really all things in New Zealand aviation, as he had seen on his visits there. He was Air Secretary, Vice Chairman of Tasman Empire Airways, Head of the Civil Aviation Branch and a Member of the New Zealand Air Board. He was, therefore, concerned intimately with both the operational side of New Zealand airlines and the legislation side in the Government. He was not sure that he should approve that in principle, it might put ideas into other peopie's heads here. But in Tom Barrow it certainly worked. And to show how well it worked from an airline point of view, Mr. Barrow had laid down that New Zealand National Airways should pay no landing fees on their internal services until their financial position looked a bit better. What a wise man! M.C.A. please copy! Obviously he worked on the principle that to rob Sholto to pay Hugh was not cricket—nor even football as played by the All Blacks.

Sir Leonard had found in Mr. Barrow the perfect vehicle for a lecture, and if he were pressed to say what sort of a vehicle, he would have to confess "a barrow"—not a common or garden barrow but a very special and distinguished one.

He proposed a very hearty vote of thanks be given to the originator of that lecture, Sir Leonard Isitt, and to Mr. Barrow.

After the Lecture a dinner was given by the Council at 4 Hamilton Place, W.1, at which the following were present:—

Dr. A. M. Ballantyne, T.D., A.F.R.Ae.S., Secretary, Royal Aeronautical Society; Mr. T. A. Barrow, J.P., A.R.A.N.Z., A.I.A.N.Z., New Zealand Air Secretary, Vice-Chairman, Tasman Empire Airways; Lt.-Col. M. C. M. Barber, D.F.C., Director of Civil Aviation, Southern Rhodesia; Air Marshal Sir John N. Boothman, C.B., D.F.C., A.F.C., Controller of Supplies (Air), Ministry of Supply; Sir John S. Buchanan, C.B.E., F.R.Ae.S., Past President; Major G. P. Bulman, C.B.E., B.Sc., F.R.Ae.S., Past President.

Mr. V. Christensen, London Manager, Scandinavian Airlines System; Mr. A. H. K. Cobb, Union Insurance Society of Canton; Dr. H. Roxbee Cox, D.I.C., F.R.Ae.S., Past President; Air Chief Marshal Sir Alec Coryton, K.C.B., K.B.E., M.V.O., D.F.C., Chief Executive (Guided Weapons), Ministry of Supply; Sir George Cribbett, K.B.E., C.M.G., Deputy-Secretary, Ministry of Civil Aviation, Previous Lecturer (1950); Mr. Leak, Trans-World Airlines.

Marshal of the Royal Air Force Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., Chairman, British European Airways Corporation; Mr. E. B. Dove, A.R.Ae.S., Member of Council; Mr. G. H. Dowty, F.R.Ae.S., Vice-President.

Mr. W. S. Farren, C.B., M.B.E., M.A., F.R.S., F.R.Ae.S., Member of Council; Sir A. H. Roy Fedden, M.B.E., D.Sc., F.R.Ae.S., Past President.

Air Marshal Sir Victor Goddard, K.C.B., C.B.E., M.A., A.F.R.Ae.S., Principal, College of Aeronautics.

Professor A. A. Hall, M.A., F.R.Ae.S., Member of Council; Mr. S. Scott Hall, C.B., M.Sc., D.I.C., F.R.Ae.S., Member of Council; Mr. N. J. Hancock, A.F.R.Ae.S., Member of Council; Mr. R. E. Hardingham, O.B.E., F.R.Ae.S., Secretary and Chief Executive, Air Registration Board; Mr. N. E. Higgs, British Aircraft Limited (New Zealand); Sir William P. Hildred, C.B., O.B.E., M.A., Director General, International Air Transport Association.

Mr. E. T. Jones, F.R.Ae.S., Member of Council; Capt. A. G. Lamplugh, C.B.E., F.R.Ae.S., Underwriter and Principal Surveyor, British Aviation Insurance Co. Ltd.

Mr. P. G. Masefield, M.A., F.R.Ae.S., Member of Council; His Excellency V. K. Krishna Menon, High Commissioner for India; Mr. J. Montgomery, London Manager, Pan American Airways System.

Mr. A. C. Campbell-Orde, C.B.E., A.F.C., Deputy Operations Director, British Overseas Airways Corporation.

Sir Frederick Handley Page, C.B.E., Hon.F.R.Ae.S., Past President; Colonel R. L. Preston, C.B.E., A.F.R.Ae.S., Secretary-General, Royal Aero Club; Captain J. Laurence Pritchard, C.B.E., Hon.F.I.Ae.S., Hon.F.R.Ae.S., Secretary, Royal Aeronautical Society, 1925-1951.

Captain R. J. Ritchie, Assistant Operations Manager, Qantas Empire Airways; Air Commodore G. N. Roberts, C.B.E., A.F.C., General Manager, Tasman Empire Airways; Sir Archibald Rowlands, G.C.B., M.B.E., Permanent Secretary, Ministry of Supply; Mr. J. G. Roxburgh, Grad.R.Ae.S., Member of Council.

The Rt. Hon. Lord Sempill, A.F.C., M.I.P.E., F.R.Ae.S., Past President; Mr. S. G. Slack, South African Airways Representative in London.

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RECENT DEVELOPMENT IN METHODS OF STRENGTH TESTING PRESSURISED FUSELAGES

by

A. W. HOTSON, B.Sc., A.M.I.Mech.E.

SUMMARY

The dangers and other disadvantages of using air pressure in the strength testing of pressurised fuselages are reviewed. A technique in which water is used instead of air is described, and its advantages considered. References are made to future test methods, and particularly to the need for the application of pressure combined with aerodynamic and inertia loads.

1. INTRODUCTION

Until recently it has been common practice to use air pressure as the means for testing pressurised fuselages for leakage and strength. Strength tests have mainly been limited to proof loading but, in a few cases, have been used to establish compliance with strength requirements.

Simple calculations of the energy stored in compressed air, together with practical experience of compressed air in other engineering applications, show that such tests can be exceedingly dangerous to personnel engaged on the test or near it, and that failure may lead to such widespread destruction that all evidence of the primary weakness is obscured and the structure is rendered useless for any further test.

The purpose of this note is to discuss these dangers and disadvantages of air pressure testing and to suggest methods of avoiding them. Experimental evidence is given in support of the suggested alternative method, and attention is drawn to the importance of testing not only for pressure strength, but also for the combined effects of pressure and external loading. This applies more particularly to pressurised passenger aircraft in which the pressure shell is practically the whole of the fuselage, including those parts of the structure most heavily stressed by inertia and aerodynamic loads.

The alternative to air pressure testing is to subject the specimen to internal water pressure while it is completely immersed in an open tank of water. Experiments so far have been limited to simple pressure tests without external loading and the failures produced by water pressure have generally been so limited that it has been possible to identify the primary cause of failure, to repair and to strengthen the specimen, and to make further tests.

2. NEED FOR PRESSURE STRENGTH TESTS

Records of strength tests at the Royal Aircraft Establishment[1] on wings and unpressurised fuselages have shown that calculations alone are unsatisfactory as a measure of strength. In these tests strength was found to vary from about 50 per cent. to about 150 per cent. of the calculated value.

There seems to be little reason to expect that the calculated strength of pressurised fuselages will be any more accurate than it has been for wings and unpressurised fuselages. Discontinuities in the structure are inevitable and these are normally the most difficult stressing problems and the cause of most premature failures.

3. DANGERS TO PERSONNEL ARISING FROM THE USE OF AIR PRESSURE

Some detail testing of windows and panels has been done in Great Britain and complete pressure cabins, or large portions of cabins, have been tested by air pressure to above the proof load.

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This experience has shown that where failure originates in the metal shell it takes the form of a violent explosion, with extensive tearing and bodily movement of the test specimen. Where the failure occurs in a window, the damage is usually limited to the window, and danger to personnel arises chiefly from flying fragments and from bodily movements of the test specimen.

The primary consideration in such tests must be the safety of test observers and any by-standers. Two methods of protection have been developed. The first, which is used when testing in the open, consists of:—

(*a*) surrounding the specimen with metal netting to check flying fragments

(*b*) anchorage of the specimen to a strong floor to reduce the risk of its moving bodily

(*c*) providing strong shelters for observers at a distance from the specimen as a protection against fragments and blast

(*d*) policing the approaches to the test area to turn back passers-by

(*e*) reducing the pressure difference to zero every time it becomes necessary for the observers to approach the specimen.

The second, and safer, method is to place the specimen inside a strong steel cylinder so that the effects of any explosion are limited to the interior of the cylinder. In this case the pressure differential is reduced to zero if it becomes necessary for test observers to enter the cylinder.

In principle, either of these methods should be satisfactory for safety to personnel, if all precautions were strictly observed, but there have been cases in which the netting and cables have failed and shelter doors have been sucked out of their frames by blast. Furthermore, there is a danger, especially in a lengthy series of tests, of familiarity leading to a general disregard of safety precautions. The risk of premature failure in the initial tests, or after some minor alteration to the test specimen, should be borne in mind particularly.

4. TECHNICAL DISADVANTAGES OF USING AIR PRESSURE

Apart from risks to personnel, there are two serious technical disadvantages in the explosive type of failure which may result from the use of compressed air.

The first is the expense and delay if the failure occurs prematurely and it is necessary to build another test specimen before the test programme can be continued. If the failure originates in the metal shell it is extremely unlikely that the specimen will be repairable.

The second is that determination of the primary cause of failure is extremely difficult owing to the extensive secondary damage caused by the explosion.

With a premature failure it is essential that the weak spot should be recognised and strengthened in the next test specimen; and even when failure occurs at, or near, the design condition the designer still likes to know what is the weakest part of the structure.

5. WATER PRESSURE AS AN ALTERNATIVE

From the foregoing it is seen that, so far as personal danger is concerned, some precautionary measures can be taken in air pressure tests but they are by no means certain to be completely effective. On the other hand, such measures do not prevent the destruction of evidence of primary weakness or the loss of the specimen for further tests.

The most obvious alternative to testing with air is to use water at the same pressure. This has commonly been used for detail aircraft parts (*e.g.* windows) and is widely used in other branches of engineering. At first sight water is unsuitable for tests on large fuselages owing to the static head and the practical difficulty of supporting a thin shell filled with many tons of water, but these objections disappear if the specimen is completely full of water while submerged in an open tank of water. A uniform test pressure can be applied by increasing the pressure of the water within the specimen, the static head and weight of the internal water being balanced by the tank water. Tests to destruction can be done with the minimum damage to the specimen, since the energy in the water is very small even when compared with the strain energy in the material of the test specimen.

6. PRELIMINARY EXPERIMENTS

In order to obtain experimental evidence, a number of destruction tests were made on a variety of small metal containers. Fig. 1 is a photograph of two five-gallon steel

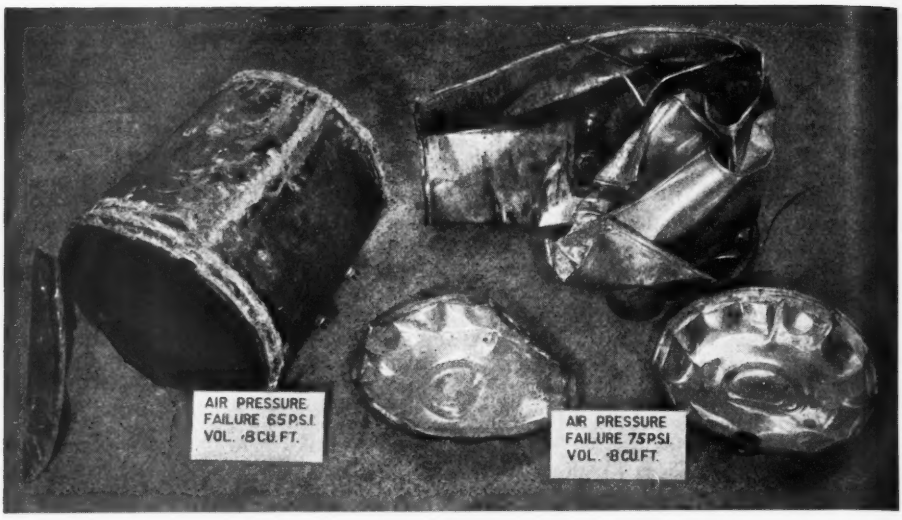

Fig. 1.
Preliminary experiments with air pressure.

drums after failure caused by air pressure. Failure of the badly distorted specimen on the right possibly originated in the longitudinal seam, the body being turned inside out. The explosion was very loud and the drum was blown against an expanded metal screen 4 ft. away. The screen was badly dented.

The explosion of the other drum was not so severe.

Figure 2 shows two one-gallon cans after test to destruction, the one by air pressure, the other by water pressure. The similarity in the origin of the two failures and the limited extent of the water failure are particularly noticeable.

7. COMPARATIVE BURSTING TESTS ON SIMPLE MODEL PRESSURE CABINS

The size and construction of the small steel containers just described were not considered suitable for more than a rough comparison of the two methods of test. Special model pressure cabin test specimens in riveted light alloy construction were designed therefore and tested by both methods. The main object of these tests was to see whether, in practice, the water pressure method would enable the testing staff to identify the primary weakness, repair and strengthen the failed specimen, and re-test to a higher failing pressure.

The models were in the form of 22 s.w.g. "Alclad" cylinders of 36 inches diameter by 70 inches long, fitted with dome ends. Figs. 3 and 4 show the dimensions and method of construction. The dome ends were fitted

Fig. 2.
Preliminary experiments comparing effects of air pressure and water pressure.

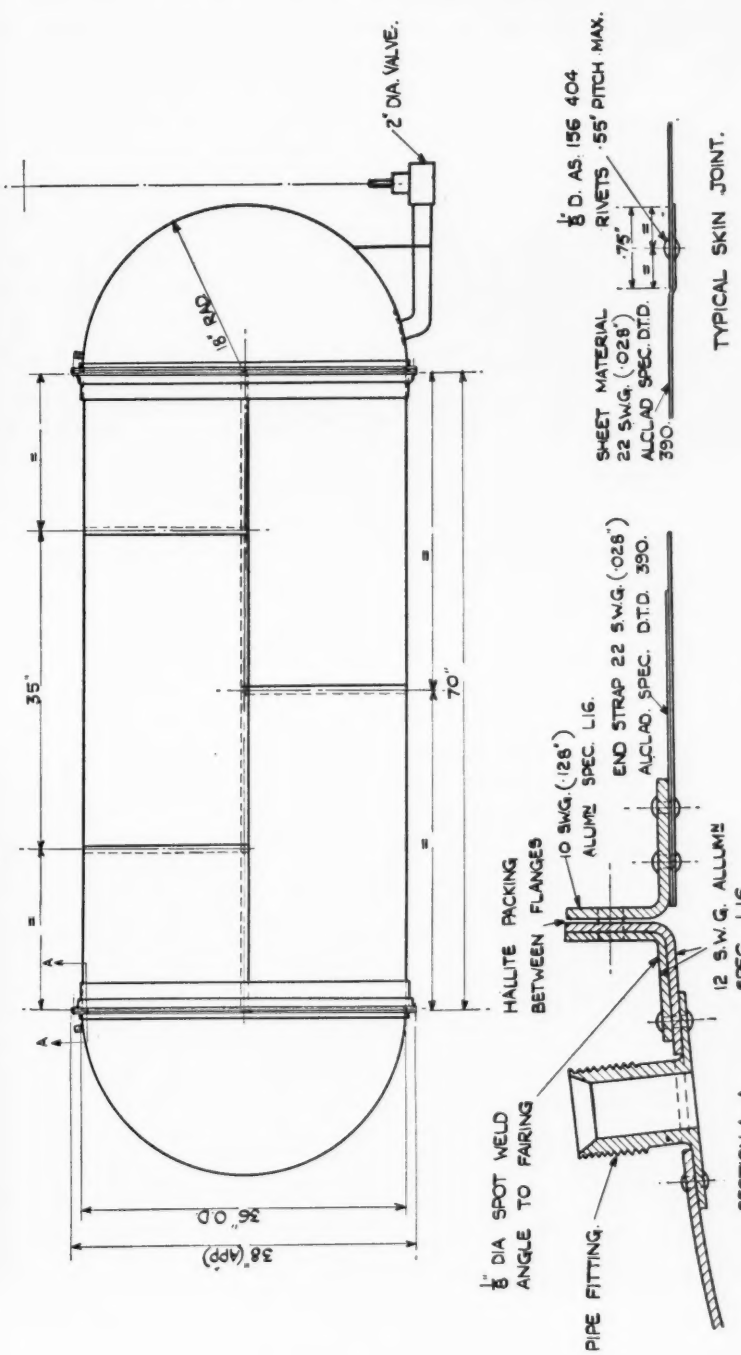

Fig. 3.
Dimensions of simple model pressure cabin.

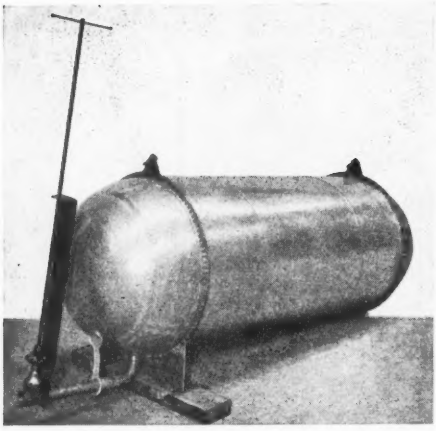

Fig. 4.
Model cabin before water pressure test.

with pipe unions for the connection of the pressure gauge and pump and a two-inch gate valve was fitted to the bottom of one dome to simplify filling and emptying of the specimen.

The method of sealing against leakage is described in Appendix I. Since the object of this type of test is strength rather than leakage investigation, the intention was to avoid leakage troubles rather than to reproduce aircraft sealing practice.

Failure occurred in the first specimen at 30 lb./in.^{2}, the rivets of one of the longitudinal joints failing in shear along practically the whole length of the joint (*see* Fig. 5). The longitudinal joints were repaired and strengthened by replacing the original $\frac{1}{8}$ in. rivets by $\frac{5}{32}$ in. rivets. One rivet in the middle of each longitudinal seam was omitted as a check on the effect of an ineffective rivet. Failure occurred in the second test on this specimen at 43 lb./in.^{2} by shearing of the $\frac{5}{32}$ in. rivets (*see* Fig. 6). The fact that a single rivet had been omitted from the middle of each longitudinal seam did not appear to affect the failing pressure or the mode of failure.

A second specimen, identical with the first and without the strengthening modification, failed at 32 lb./in.^{2} by shear of the $\frac{1}{8}$ in. rivets in the longitudinal seam. The longitudinal seams were re-riveted with $\frac{1}{8}$ in. rivets, the middle rivet being omitted from each seam. Failure again occurred at 32 lb./in.^{2} in the same manner as before, the missing rivets having no apparent effect. In both tests on this specimen, the volume of water passing through the pump was

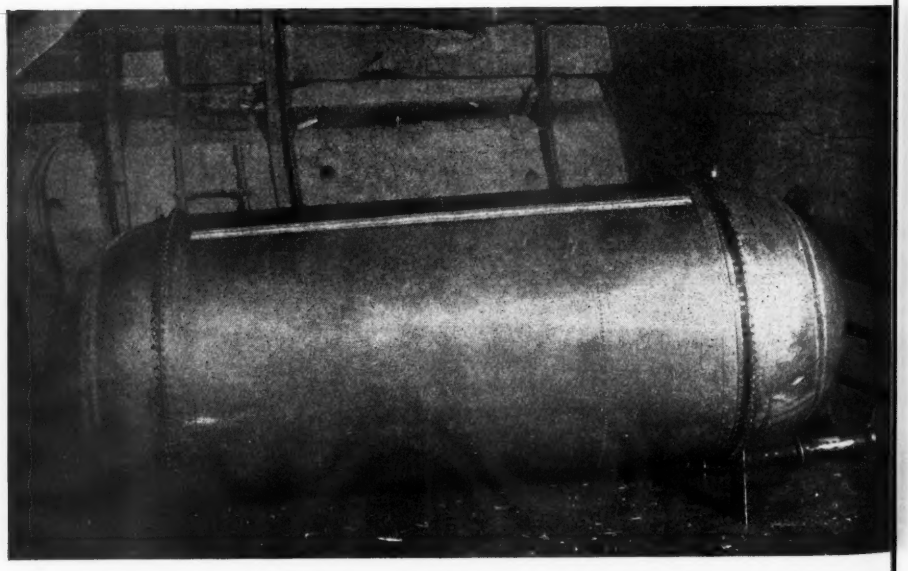

Fig. 7.
Model cabin before air pressure test.

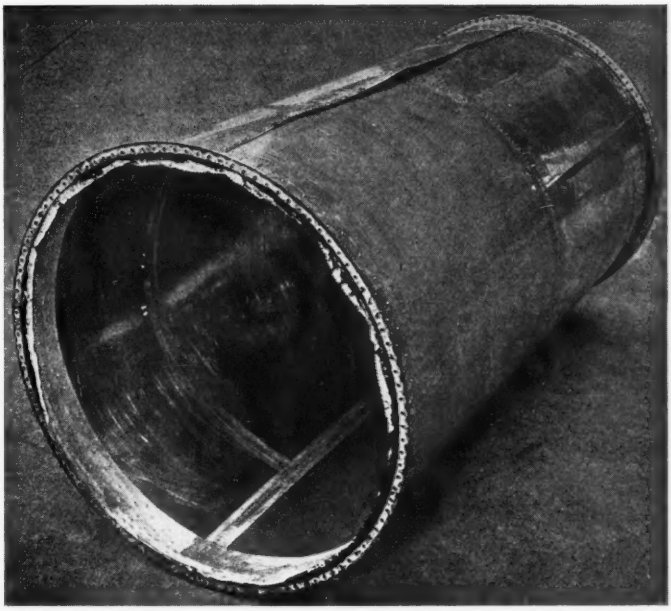

Fig. 5.
Initial failure by water pressure.

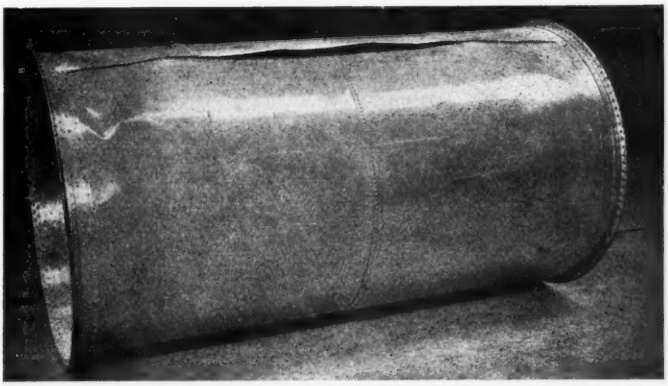

Fig. 6.
Second failure by water pressure.

measured. The total volume to failure in both cases was 0.22 ft.^{3} in three minutes.

For comparison with the alternative method a third specimen, identical with the others, was tested to destruction with compressed air. This specimen, shown in Fig. 7, was tested in a strong concrete chamber the open end of which was boarded over by heavy timbers. Failure occurred at 30 lb./in.^{2} with a loud explosion accompanied by blast which was felt by observers 100 ft. away through small gaps between the heavy timbers. The failed specimen is shown in Fig. 8. One longitudinal seam failed in shear and it appears, from the previous water tests, that this was primary.

A summary of the actual and calculated failing pressures on these three specimens is given in Appendix II.

8. PROPOSALS FOR INSTRUMENTATION WHEN USING THE WATER METHOD

The means for making test observations require certain modifications when changing over from the air method to the water method. These observations include visual examination of skin buckling, measurement of strains and deflections, and the detection of leaks. Proposals for instruments and observation technique, based on some preliminary experimental work, are now described.

8.1. Visual examination

Assuming that sufficient illumination is provided, the upper half of the specimen may generally be observed through the free surface of the tank water. Side windows in the tank, particularly if the tank is above, or partly above, ground, provide a means of observing the lower portions. An alternative method, which has been used successfully, consists of suspending the specimen by a loop of cable at each end so that it may be partially rotated during the test to bring any desired portion of the specimen near the surface of the water for detailed examination.

Experiment has shown that adequate underwater illumination can be achieved by electric lights in watertight portable housings.

Fig. 8.
Failure by air pressure.

8.2. Strain gauging

Figure 9 shows a small specimen fitted with strain gauges sealed against water by means of "DiGel." Tests with this type of strain-gauge installation have shown that it will be possible to obtain satisfactory strain measurements in spite of the use of water as the pressure medium.

8.3. Deflection measurements

Some preliminary work on equipment for measuring deflection is indicated in Fig. 10, which shows an electrical resistance gauge which gave promising results when used in water.

8.4. Leakage detection

In the strength testing of pressure cabins it is suggested that sealants should be more generously applied than is the normal practice in aircraft production. Leakage should be measured on the complete, fully representative, production aircraft after completion of all strength tests.

The strength tests should avoid the delays which are likely to be incurred if leakage troubles occur and the development of sealing technique becomes a major part of the job.

Nevertheless some leakage will occur, especially at the higher pressures, and it is desirable to locate its source. This can obviously be done by staining the water supplied to the pressure pump, but there is the possibility of prolonged leakage causing clouding of the tank water.

Figure 11 illustrates an experiment designed to overcome this difficulty.

The pump water was coloured with potassium permanganate and the tank water was charged with hydrogen peroxide and sulphuric acid. The principle used was that a purple solution of potassium permanganate loses its colour when treated with an acid solution of hydrogen peroxide. Any clouding produced by excessive leakage can be rectified by the addition of more peroxide solution to the tank water.

Good results were obtained with the following quantities, the specimen showing no sign of attack by the weak acid solution after being immersed in it for several days.

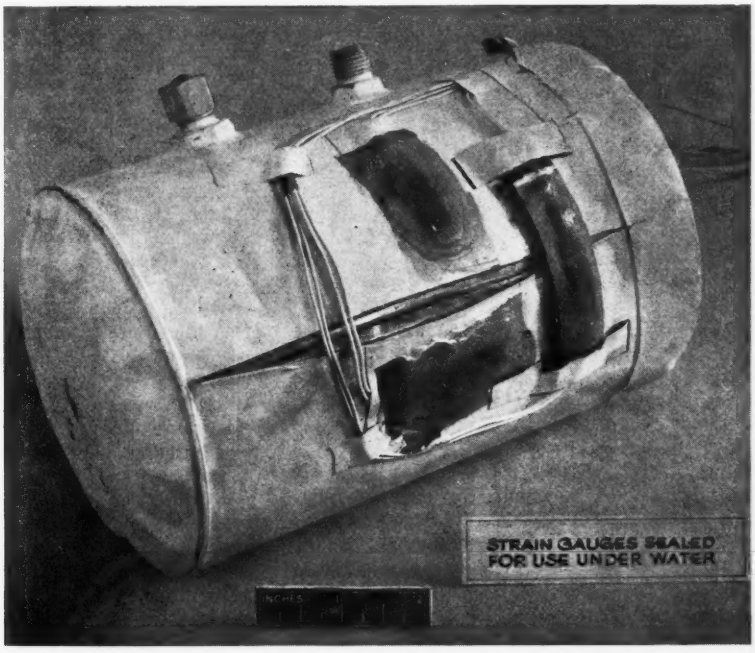

Fig. 9.
Strain gauges sealed for use under water.

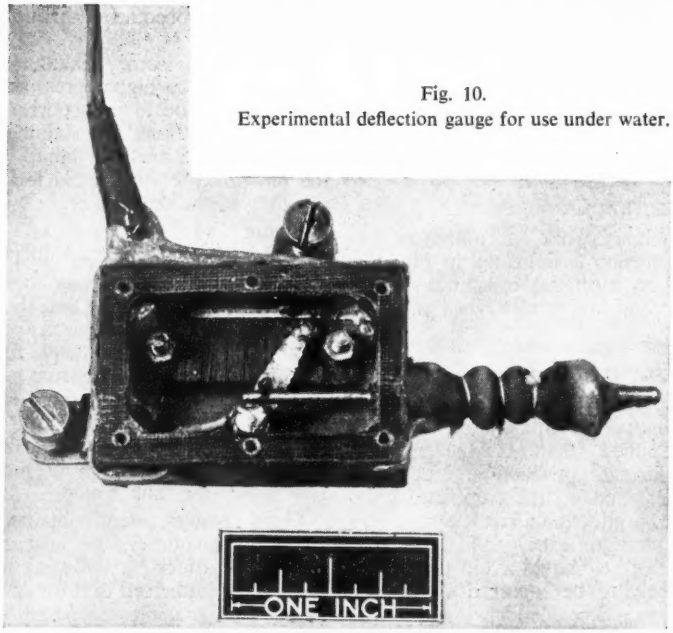

Fig. 10.
Experimental deflection gauge for use under water.

Potassium permanganate—0.25 oz. per gallon of water.

Hydrogen peroxide—0.25 fluid oz. of 40 Vol. peroxide per gallon of water or *pro rata* for 20 Vol. or 10 Vol. peroxide.

Sulphuric acid—1 fluid oz. of 1:1 sulphuric acid per twenty gallons of water.

9. RECENT FULL-SCALE *AD HOC* TESTS MADE BY THE AIRCRAFT INDUSTRY

Since the completion of these experiments at the R.A.E., the Aircraft Industry has made a few pressure tests by the water method on fully representative specimens of pressurised fuselages. The specimens varied from complete fuselages to sections of fuselages.

Unlike the simple shell models tested at the R.A.E., these *ad hoc* specimens included the frames and floors of the fuselage structure, together with fully representative discontinuities such as doors and transparencies.

Failures have been of two types:—

(*i*) Primary failure in the metal skin of the pressure shell, as in the R.A.E. model tests. The damage tended to be local, the strain energy in the specimen expending itself by expelling water through the fracture.

(*ii*) Primary failure in the internal structure of the fuselage. This type of failure is most likely to occur where the section of the fuselage is maintained in a non-circular shape by internal structure. If the pressure shell is not punctured the damage may be less local, since the strain energy in the specimen tends to release itself by distorting the structure progressively from the original failure.

These full-scale tests have included the successful use of strain gauges, electrical deflection-measuring instruments, underwater lighting and water staining. Most of the tests have been done in tanks without roof cover and it has been found that, in addition to the more obvious disadvantages of working in the open, it may be difficult to observe visually owing to disturbance of the water surface by wind or rain.

10. TESTS COMBINING PRESSURE WITH EXTERNAL LOADS

Pressure cabins are required to withstand not only the loads due to internal pressure,

but also those due to aerodynamic and inertia forces. It has been normal practice until recently to separate these loading actions in the test laboratory, the "cabin" being tested under pressure loads alone, and the "fuselage" subjected only to the aerodynamic and inertia test loads.

In flight the pressure and aerodynamic loads occur simultaneously, and it will probably be necessary to combine these loading actions in future strength testing. This will complicate the testing technique but will be necessary, to varying degrees with different types of aircraft, for structural efficiency and for reasons of safety. The complication arises from the need to use water as the pressure medium.

With an orthodox pressurised passenger aircraft, the most difficult design features from the pressure strength point of view are:—

(*a*) the fuselage nose and its transparencies
(*b*) the nose undercarriage housing
(*c*) the doors and windows
(*d*) the wing joint to the fuselage
(*e*) the rear pressure bulkhead.

Of these, (*b*) (*c*) and (*d*) are primary stressing problems where external loads are considered, the wing joint to the fuselage being probably the most important feature as regards simultaneous pressure and external loading.

Wing-to-fuselage joints tend to be of two general types. In the one, the wing closes an opening in the fuselage so that the joint must be made pressure tight and the pressure tends to separate the wing from the fuselage. In the other, the fuselage is in itself a complete pressure chamber having an unpressurised recess into which the wing is assembled. Both types have large flat surfaces subjected

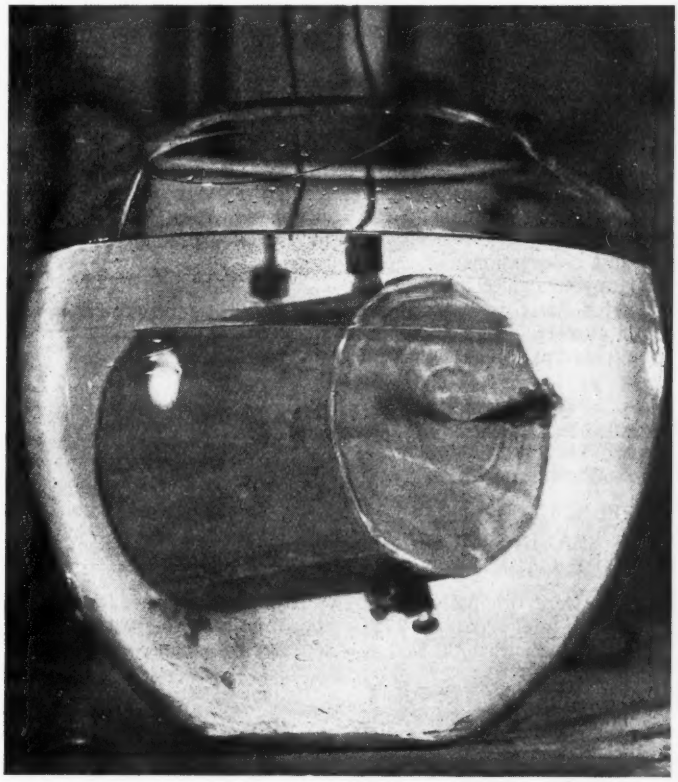

Fig. 11.
Leak detection.

to pressure combined with external loads and involve serious discontinuities in the pressure shell.

Testing of the joint under pressure combined with external fuselage and wing loads, while being fully representative of flight conditions, would involve testing the complete wing and fuselage together in a test frame equipped for the application of water pressure. For present-day orthodox designs there are strong arguments for separately testing the wing on a portion of fuselage and the fuselage on a portion of wing. It is suggested therefore that a reasonable compromise would be to test the joint under pressure combined with wing loads, by pressurising the portion of fuselage used to hold the wing, and to test under pressure combined with fuselage loads in the fuselage test.

11. CONCLUSIONS

Compressed air should not be used for the strength testing of pressure cabins because of the dangers to personnel and the risk of explosive failure causing such widespread damage that all evidence of the primary weakness in the specimen is obscured and the specimen is beyond repair for any further test.

Water pressure provides a means whereby these difficulties can be overcome and the use of water does not raise serious obstacles to the making of test observations.

Future test equipment and technique will need to provide for tests in which the external wing and fuselage loads are combined with internal pressure applied by water.

REFERENCE

1. WALKER, P. B., M.A., Ph.D. Records of Major Strength Tests. R.A.E. Report Structure 44, A.R.C. 12,601.

APPENDIX I

METHOD OF SEALING MODEL PRESSURE CABINS

The riveted joints were originally sealed on the inside with an undercoat of 1751 "Bostik Adhesive" covered with 1790 Sealing Compound (both made by B.B. Chemical Co. Ltd.), and bolted flange joints with $\frac{1}{16}$ in. Hallite packing in conjunction with Bostik.

The application of pressure showed that the leakage rate was unsatisfactory. The joints were re-sealed on the inside with waterproof adhesive tape. The sequence of sealing was as follows.

One coat of "Necol" cement (made by Imperial Chemical Industries) No. 310 or 205 was applied to the metal and while it was still wet the fabric strip was put on. Another coat of "Necol" cement was applied over the fabric and allowed to dry. After three hours, two coats of 33b/803 cellulose varnish were applied, allowing an hour between coats. This gave the fabric a glazed finish.

Fabric $2\frac{1}{2}$ in. wide was used on the skin joints, and 6 in. wide at the end cap flange joints. The fabric was Aircraft Fabric F.19, 80 lb./in. breaking strain on the warp pull, and weighing 5 oz./yd.[2]

APPENDIX II

SUMMARY OF ACTUAL AND CALCULATED FAILING PRESSURES OF THE MODEL PRESSURE CABINS

Table I gives the failing pressures obtained from the tests and the failing pressures calculated from A.P.970 for the two contingencies; (*a*) Failure of joint, (*b*) 2 per cent. bearing.

TABLE I

Test No.	*Model No.*	*Rivet size in longitudinal joint*	*Test failing pressure (lb./in.²)*	*Calculated failing pressure (lb./in.²)*	
				Failure of joint	*2% bearing*
1	1	$\frac{1}{4}$ in	30	35.4	30.5
2	1	$\frac{5}{32}$ in	43	43.0	38.1
3	2	$\frac{1}{4}$ in	32	35.4	30.5
4	2	$\frac{1}{4}$ in	32	35.1	30.2
5	3	$\frac{1}{4}$ in	30	35.4	30.5

It should be noted that in Tests 2 and 4 the middle rivet was omitted from the longitudinal seams.

THE ACCIDENTAL CARRIAGE OF INSECTS ON BOARD AIRCRAFT*

by

MARSHALL LAIRD, M.Sc., Ph.D.

SUMMARY

Accidental dispersals of medically and agriculturally undesirable insects by sea and air transport are discussed, with attention to the relative importance of the roles of ships and aircraft. World-wide records of insects found on board aircraft and discovered to have been introduced at airfields are briefly reviewed, and consideration is given to ways of meeting the problem by insecticidal treatment and airport insect control. It is felt that the insecticidal treatment of aircraft, even when provided for by comprehensive international regulations and conscientiously undertaken, does not alone provide sufficient protection against insect introductions, and that greater attention should be paid to the preventive aspects of the problem, with particular regard to the control of insects of both medical and economic significance at international airports.

INTRODUCTION

The past quarter of a century has seen the development of a new problem of first importance to the fields of medicine and agriculture. During this period, the great and rapid advances which have taken place in both international and internal air transport have introduced the hazard of noxious insects being accidentally carried on board aircraft from one country, or part of a country, to another. For the most part, the considerable literature on this topic is scattered throughout scientific journals normally accessible only to biologists. The present account has been prepared with the object of bringing both the hazard and the means of its solution to the attention of those directly concerned with aviation, who, while being concerned with all aspects of the problem, have often proved to be inadequately informed on it.

SHIPS AND AIRCRAFT

In the past, ships have been the means of introducing a large number of insect species into new areas. Many of the common insects which live on the person, in the habitations, and in the food materials and refuse of man were formerly confined to quite restricted areas, but today, because of the development of commerce, they have attained world-wide distribution. Some species, parasites such as lice and fleas, have so faithfully accompanied man in his wanderings that their present range coincides with that of man himself. Certain of the mosquitoes, those "domestic" species which exhibit preference for man-made breeding places, were spread far and wide in the days when sailing ships carried their water supplies in open casks. Thus *Culex fatigans*, a domestic mosquito now cosmopolitan, was taken by sailing vessel from Mexico to Hawaii in 1826[1]. This species, and the widespread Indo-Pacific mosquito *Aëdes notoscriptus*, were probably introduced into New Zealand in like manner[2].

Other domestic insects which do not require aquatic larval habitats as do mosquitoes, houseflies and cockroaches for example, adapt themselves still more readily to shipboard existence. Many of these have long since become cosmopolitan. Apart from primarily domestic insects, numerous species of economic importance are able to survive protracted sea journeys, especially when in the larval state and in the presence of suitable food material being carried as stores or cargo, or when in quiescent pupal stage. Of pests which in the past have

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extended their range to New Zealand in this manner, the Diamond-back Moth (*Plutella maculipennis*) and the White Butterfly (*Pieris rapae*) are examples. The caterpillars of both these species, besides feeding on cabbages and other vegetables grown for human consumption, do great damage to related crops grown for stock-feeding purposes. The Diamond-back Moth reached New Zealand late in the last century and is now a major pest there, its depredations being responsible for heavy economic losses annually[3]. The White Butterfly was a later arrival, and was first observed in Hawkes Bay in 1930[4]. By 1935-36 this butterfly had spread throughout the country, and its caterpillars were causing havoc to cabbage and allied crops in farms and market gardens[5]. The control of these two pests has been a primary concern of New Zealand agricultural scientists for the past twenty years. Although partial control has now been achieved by biological means, expenditure in this direction, together with continuing economic losses, remains heavy.

A great number of undesirable insects are unsuited to withstand the conditions encountered during lengthy sea voyages. For the most part these are species for which suitable larval habitats are unavailable on vessels, and which in the adult state either have a very brief existence, or by their habits cause such continual annoyance to man as to render their survival throughout a lengthy voyage unlikely. Most of the anopheline mosquitoes of importance in the transmission of human malarial organisms require natural larval habitats, such as ground pools of various kinds, and thus cannot breed on board ships. Shipboard survival of adult mosquitoes of this and other kinds, of similar habits, is rendered less likely in direct proportion to the duration of the voyage, if the insects are in the normal active phase during which both sexes must feed repeatedly. The males die, being deprived of their natural food (juices of plants, and so on) while the persistent biting habits of the females lead to their continual reduction in numbers by swatting and other control measures. If, on the other hand, anopheline adults board a ship in readiness to undergo hibernation, their chances of survival are considerably enhanced. Thus, on two occasions in 1929, living but quiescent female anophelines were discovered between decks, and in an insulated hold, of ships which had reached Auckland, New Zealand, from the East Indies and Malaya[2].

If large numbers of *Anopheles* come aboard a vessel sailing on a voyage of short duration, there is a good chance that some of them will survive and become established at the port of arrival. Thus malaria was unknown in Mauritius before the second half of the nineteenth century, when anopheline mosquitoes were introduced from Madagascar (a distance of 550 miles) on board a sailing ship[6]. These insects became established in Mauritius, and after biting Indian or African coolies who still carried in their blood malaria parasites which had been acquired in their homelands, the anophelines initiated an epidemic which was responsible for 32,000 deaths during 1867-68 alone. Again, it is considered that river traffic was responsible for the disastrous introduction of *Anopheles gambiae* from the Sudan into the Nile Valley, some ten years ago[7]. An epidemic of malaria resulting from this introduction is stated to have been the cause of 130,000 deaths in 1942-43[8]. A further illustration of a probable shipborne introduction of *Anopheles* is that of *A. gambiae* from West Africa into Brazil, which took place in, or shortly before, 1930[9]. The distance concerned is considerable (2,050 miles), but during the period in question fast French destroyers were covering the mail run from Dakar, West Africa, to Natal, Brazil, in less than 100 hours. At the same time an air service was being inaugurated between Dakar and Natal, and the claim has been advanced that pioneer aircraft were responsible for this introduction. Although it can never be established with certainty which of the two means of transport brought *A. gambiae* to Brazil, and there is little doubt but that either of them could have been to blame, the available evidence tends to support the shipborne rather than the airborne hypothesis[9].

The chief significance of aircraft as a means of accidentally transporting insects from one country, or part of a country, to another, lies in the relatively brief flying time required for journeys which take many days or weeks by surface transport. Griffitts and Griffitts[10], Hicks and Chand[11] and other investigators established the fact that mosquitoes are able to survive air journeys, while the author[12], experimenting with *Aëdes notoscriptus*, demonstrated that exposure to the aircraft environment during a flight of

12,452 miles spread over an eighteen-day period and involving transitions from southern hemisphere winter conditions to northern hemisphere summer conditions and vice versa, did not significantly alter the life span of those mosquitoes allowed to feed at normal intervals. That anophelines, provided they are spared the hazards of insect control measures, are capable of the normal life processes following an air journey to a new locality was demonstrated by Sicé *et al*[13]. These investigators had adult *A. gambiae* sent by air from the French Sudan to Marseilles, the insects being enclosed in test tubes without any special measures for their welfare being taken. A large proportion of these mosquitoes reached Marseilles alive, and laid eggs which developed normally in laboratory breeding places at ordinary summer temperatures. Adults were reared, and these duly mated.

Agricultural and other economic pests rarely have the opportunity of voluntarily entering ships, other than those berthed at river ports or at seaports in relatively undeveloped areas. Such insects have much more frequent opportunities of voluntarily entering aircraft. International airports being less frequently located in heavily built up areas than are docks, a much wider range of breeding places suited to the requirements of both domestic and non-domestic insects exists within easy reach of them. Moreover, as a further consequence of this fact, the chances of insects introduced from some other area establishing themselves in the vicinity of an airport are generally better than those of insects introduced into an urban dock area.

INSECTS COLLECTED ON BOARD AIRCRAFT

Great numbers of insects have been collected from aircraft in many parts of the world. As early as 1928, Montgomery[14] remarked on the new problems concerning plant quarantines which had arisen from the development of airlines between Cuba, South America, and the United States. Other investigators soon devoted attention to these problems, and in 1929 numerous insects were collected from bouquets taken from passengers landing in the U.S.A. at the conclusion of the first flight of the dirigible "Graf Zeppelin" from Germany[15]. By 1939, Whitfield[16] was able to publish a list of more than 3,759 insects which had been collected from aircraft up to that time. Lists published since then include those of Pemberton[17] (Hawaii—11,448 specimens), Dethier[18] (Central Africa—more than 2,000 specimens), Mendonça and Cerqueira[19] (Brazil—40,168 insects and 153 spiders) and Laird[20] (New Zealand—548 insects and 9 spiders).

These collections have included representatives of numerous species dangerous from both medical and economic points of view. Thus, considering only the mosquito genus *Anopheles* (numerous species of which transmit the parasites of human malaria), Galvão[7] has recently listed 534 examples representing 19 species as being found in aircraft by various investigators over a period of sixteen years. There is every reason to believe that only the long standing vigilance maintained by most of the responsible authorities has thus far prevented the occurrence of really devastating introductions of insect carriers of disease-causing organisms by means of aircraft.

There has been a tendency to allow the health aspect of the problem to overshadow the agricultural one. The agricultural aspect, however, is of at least equal importance, particularly in countries like New Zealand which depend so largely for their prosperity on primary production. Numbers of actual or potential agricultural pests have been intercepted on board aircraft, and as shown in the following Section, although there is as yet no certain instance of an important insect carrier of disease organisms becoming established in a new country following its accidental importation by aircraft, such introductions of important plant pests have actually occurred.

INTRODUCTIONS OF INSECTS BY MEANS OF INTERNATIONAL AIR TRANSPORT

A few cases have been recorded of foreign mosquitoes eluding aircraft insecticidal treatment and beginning to breed on or near airfields. Thus a fully developed larva of *Anopheles albimanus* was found in a canal near a runway of Boca Raton Army Air Field, Florida, on 16th May 1944[21]. *A. albimanus*, one of the principal carriers of the causal organisms of human malaria in Central America and the Caribbean region, had not been reported from Florida since the discovery of a limited shipborne introduction in 1904. On 1st May 1944, an Army aircraft

had flown to Boca Raton from Puerto Rico. There was no record of this aircraft's having been sprayed, and as the interval of a fortnight between the flight and the discovery of the larva was sufficient for the full larval development of *A. albimanus*, it appears likely that at least one female of this species had escaped from the aircraft on its arrival[21]. Fortunately, the anopheline failed to become established, no further larvae being discovered at Boca Raton. Again, larvae of two Australian mosquito species were recorded near Nandi* Airport, Fiji, in 1943 and 1948[22]. In both these cases, the invasion foci were eradicated by the prompt action of the mosquito control organisation of the Fijian Medical Department.

These instances serve to illustrate the importance of the maintenance of insect control organisations at international airports. Such organisations as do exist are for the most part concerned primarily with mosquito control, and in recent years there have been instances of agricultural pests eluding aircraft insect control and becoming established in new habitats. Thus air transport between South Africa and Kisimu Airfield was considered responsible for the introduction of the Eucalyptus Weevil (*Gonipterus scutellatus*) into Kenya and Eastern Uganda[23], while Pemberton[24] thought it probable that the Oriental Fruit Fly (*Dacus ferrugineus* var. *dorsalis*), a most serious pest of fruit trees, was introduced into Hawaii in infested fruit carried in aircraft from Saipan. Van Zwaluwenburg[25] listed 28 insects, including nine species injurious to agriculture, as having become established in Hawaii between 1944 and 1947, and considered that aviation was chiefly responsible.

INSECTS AND INTERNAL AIR TRANSPORT

Once established in a new habitat, insect species spread at varying rates according to their rate of reproduction and degree of adaptation to the new environment. Their dispersal rate may be accelerated by various forms of transport. Thus Galvão[7] dealt with a number of records of the carriage of mosquitoes by trains, automobiles and other forms of surface transport. Here again, air transport provides a unique and speedy means of dispersal for insects within the bounds of one particular country or continent. In recent years the Japanese Beetle (*Popillia japonica*), the larvae of which do great damage to pasture plants in many parts of the U.S.A., has leapfrogged across wide tracts of the North American continent on board aircraft. This agricultural pest was discovered in aircraft landing in Canada from the south in 1944-45. Two adults of *P. japonica* were found in aircraft at an airport near Montreal[26], while Gardiner[27] recorded the discovery of one in another aircraft also of a single beetle which had presumably escaped from an aircraft, on an airport at Hamilton. A further instance in this connection concerns the German Wasp (*Vespa germanica*), which has become a pest in the northern parts of the North Island of New Zealand since it was first noticed there in 1945. This species has not yet spread to the South Island of New Zealand, but its chances of doing so are enhanced because of internal air transport, for *V. germanica* is now abundant at Whenuapai Airport (near Aukland) and has been observed to fly aboard aircraft there[20].

THE CONTROL OF INSECTS IN AIRCRAFT

Duguet[28] has recently discussed this question in some detail, and interested readers are referred to his paper for an outline of the World Health Organisation approach to the problem. Briefly, the means of control are fumigation, insecticidal aerosol sprays and residual insecticides. Fumigation is too cumbersome and time-consuming a process for routine use in aircraft, but a combination of aerosol spraying at each stage of an air journey, and monthly treatment of interior surfaces with a residual insecticide such as D.D.T., affords a satisfactory substitute offering a high level of protection against insect introductions. Aerosol spraying alone is the practice most generally followed today.

An aerosol is defined by David and Tew[29] as "a dispersion in air of insecticide solution as particles, the diameter of which falls within the range of 5-25 microns."* Aerosol mists have great powers of penetration and remain in suspension for considerable periods; for these reasons they contact many more insects and have a higher insecticidal value than do the sprays from old-type spray guns. The formulae of aerosols, arising from those developed in the U.S.A. during

*Also called Nadi—authorities differ—ED.

*A micron is 0·001 mm.

the Second World War for use in insecticide "bombs," are based on various proportions of the insecticides pyrethrum and D.D.T. (dichlorodiphenyltrichloroethane), with Freon 12 (dichlorodifluoromethane) as a propellant and solvent, and some other chemical as an auxiliary solvent for the D.D.T. Pyrethrins exert an immediate knock-down effect on insects, the apparent results of which may be illusory in that light dosages often permit later recovery, while D.D.T. is slower to take effect but has an irreversible action. The aerosols in common use are non-toxic to humans and non-injurious to most of the materials of aircraft construction, although David and Tew[29] and Whittingham and Galley[30] have drawn attention to the presence in some formulae of such solvents as methylene chloride which can initiate or accelerate the crazing of stressed plastics. Due care should be taken to see that aerosols intended for use in pressurised aircraft are free from crazing agents.

There is diversity of opinion as to when spraying can best be done. If the maximum insecticidal effect is to be assured, spraying should be undertaken at some stage after loading and embarkation, but before unloading or disembarkation. Spraying before loading and embarkation is recommended by some investigators on the grounds that insects might find fresh sheltering places in cargo and passengers' effects. In the author's opinion, so many potential sheltering places for insects already exist on board aircraft that this risk is altogether outweighed by that of insects coming aboard following the completion of spraying and dispersal of the aerosol mist, both secreted in luggage and cargo, and voluntarily, when the doors are opened to admit passengers and crew. Spraying after unloading and/or disembarkation introduces the danger that insects might leave the aircraft at the airport of arrival before insecticidal treatment takes place.

From the point of view of the comfort of passengers and crew, the most satisfactory times are at the start of the flight or during flight. Spraying on arrival at the destination involves what is understandably viewed as a tedious period of waiting before disembarkation, for the aircraft must remain sealed for at least five minutes following the completion of spraying so as to ensure that the aerosol mist is not dispersed before it has had time to exert the maximum insecticidal effect. Spraying during flight has the advantage of involving no delays on the ground, and is practised by some airways companies and stipulated by some States[28]. This procedure, however, has disadvantages as regards the insecticidal effect attained. Furthermore, it is impracticable in pressurised aircraft, for in these the ventilating apparatus cannot be turned off during the five minute "holding period," a necessity if the aerosol mist is not to be too quickly dispersed by air currents[28].

Research undertaken on the reactions of the mosquito *Aëdes notoscriptus* to the aircraft environment[12] showed that this species becomes inactivated as a result of exposure to air temperatures of less than 10° C. and to heights of more than 10,000 feet. David and Bracey[31] discovered that a related mosquito, *Aëdes aegypti*, is much more susceptible to insecticidal sprays when in flight than when at rest. During flight through spray mists, this insect, also houseflies and other flying insects[32], collect many insecticide particles on the wings. After coming to rest again, their endeavours to clean their wings result in the spray droplets being distributed about their bodies. David[32] found that if the wings of mosquitoes and houseflies are removed immediately after the exposure of these insects to oily spray mists, the kill as recorded 24 hours later is 50 per cent. less than that among insects subjected to the same treatment but allowed to retain their wings. Although there is still a lack of knowledge as to how aerosols produce their insecticidal effect[28], it is certain that this effect is greater on winged than on wingless insects. Spraying during flight at normal operating heights thus not only involves the risk of too rapid dispersal of the aerosol, but also the probability that many at least of the insects on board, being inactivated as a result of exposure to low air pressures and temperatures, will not be touched by enough insecticide to kill them. For these reasons, the author does not consider this procedure to be adequate.

Spraying following embarkation offers better results. There has been controversy as to whether this should be undertaken before or after the starting of the engines. Some authors (*e.g.* McMullen[33]) have indicated that there is a tendency for mosquitoes to settle on vibrating surfaces following the starting of the engines, while others[34] have claimed that vibration prevents mosquitoes from resting during a flight. McMullen[33], however, was quoting an observation made in

1932 in a Fokker trimotor having internal vibrations considerably in excess of those in modern aircraft. Duguet[28], while recognising that internal vibration is a factor of much reduced importance in modern aircraft, nevertheless recommends that pre-flight spraying should be done five minutes before the engines are started. Observations on caged mosquitoes in a DC-3 aircraft indicated that these insects do not display undue activity when the engines are started up or during taxying, but that they start to fly in an agitated fashion when the engines are fully opened out just prior to the take-off run, their behaviour not returning to normal until about five minutes after take-off. The author accordingly considers that, bearing in mind that aerosol mists can be expected to exert their highest toxicity against insects actually flying through them, the most favourable time for pre-flight spraying in piston-engined aircraft, from the point of view of insecticidal efficiency, is between the testing of the engines at full revolutions during final cockpit drill, and the start of the take-off run[12]. This procedure unfortunately has disadvantages for efficient airfield operation.

In view of the undesirability of delaying aircraft about to take off when they are actually at the end of the runway, also of the safety hazard which may be introduced if too long a time is allowed to elapse between the running up of the engines and take-off, some other solution must be sought. This might well take the form of spraying immediately after take-off, while winged insects on board are still active, were it not for the fact that air currents set up at this time might cause premature dispersal of the aerosol mist. All in all, Duguet's recommendation that pre-flight spraying should be undertaken five minutes before the engines are started seems to offer the most satisfactory compromise between maximum insecticidal efficiency and maximum efficiency of airfield operation, especially when it is considered that with the increasing use of turbo-jet engines the vibration-activation factor should disappear altogether.

The most satisfactory means of spraying following loading and embarkation would be some form of built-in apparatus having valves opening into all enclosed spaces and operated by remote control from the cockpit[28]. If manually-operated aerosol "bombs" are used, many places which cannot be reached from within the aircraft, such as wheel cavities and baggage compartments opening to the exterior, must be treated by ground personnel before departure from the tarmac.

Consider now spraying on arrival at the destination, which involves a delay of at least five minutes before disembarkation, a delay much more resented by those on board than an equivalent one at take-off. If insecticidal treatment was not undertaken at the airport of departure, this procedure entails the risk that insects travelling in the wheel cavities might escape before spraying. In this connection, Melleney (*vide* Cameron[35]) has made the observation that "the retractable undercarriage offers a haven for winged insects, a haven which is automatically emptied before the plane lands." Provided that it is done from within the aircraft before the doors are opened, and a sufficient "holding time" is maintained, spraying on arrival is otherwise perfectly satisfactory insecticidally; for mosquitoes become active during and immediately following landing as a response to the stimuli of a sudden increase in air temperature and air pressure followed by a cessation of vibration as the engines are stopped[12]. If hand-operated dispensers are used, a ground operator must be available to treat the wheel cavities as soon as possible after arrival and the external baggage compartments as soon as these are opened, but the adoption of built-in spraying equipment would obviate the need for any ground assistance. Passenger resentment, a major disadvantage in spraying on arrival, could be largely quieted by the addition of a suitable brochure, explaining the reasons underlying this procedure, to the literature already made available to passengers.

There is a regrettable lack of uniformity in the enforcement and practice of insecticidal spraying in aircraft, by the various States which are signatories to the International Sanitary Convention for Aerial Navigation of 1933/44[28]. As few States require aircraft leaving their territories to be sprayed, and as the various airlines and military organisations differ in the spraying instructions issued to air crews, insecticidal treatment on arrival, undertaken by ground personnel, today constitutes the most generally practised means of protection against airborne insect introductions. This procedure has the disadvantages already referred to, and at the same time makes no allowance for possible emergency landings at airfields where the

necessary equipment for insecticidal treatment is not available. It is also open to the failure of the human element involved. While it is probably a fair assumption that the majority of spraying operatives properly instructed in the reasons for, and execution of, their task perform their duties in a conscientious manner, it sometimes happens that the orderly sent out to meet arriving aircraft is an odd-job man who has proved his incapacity to cope with more technical tasks. In this connection, the author recalls an experience on arrival in Australia from the Moluccas during 1946. On reaching Darwin, the last stop having been made at Morotai where anopheline mosquitoes were abundant, instructions were received from the control tower to await the arrival of a spraying operative before opening the doors of the DC-3. In due course the man arrived, and opening a door, which he left wide open, thrust in an aerosol "bomb" while still standing outside, manipulated the valve, and immediately announced that spraying having been completed the passengers were free to disembark!

Although this may be an extreme case, it is an example of what can happen as a result of the failure of the human element, even where adequate spraying regulations exist, and the task is duly logged as having been completed as required. It may happen, also, that when an aircraft is carrying officials of high rank there is a tendency on the part of the captain to save them the time and perhaps discomfort entailed in insecticidal spraying. Service personnel on occasion may find themselves in an awkward position where matters of rank are involved. A Wing Commander of the Royal Air Force is recorded as having been most indignant at the insistence of an Ohakea (N.Z.) spraying orderly that his aircraft, which had just arrived following a long and exhausting flight, remain closed up for five minutes following the completion of spraying. He claimed that no insects were ever present in his aircraft, and was later somewhat taken aback when shown a tube containing a dozen insects, some still dying from the effecs of spray, which had been collected from his gun turrets.

DISCUSSION AND CONCLUSIONS

While ships have played a most important part in the transport of insect pests from one country to another, aircraft have introduced the new hazard of rapid transport which permits the carriage across long distances of species having extremely short life spans. Insects unable to survive protracted sea voyages because of the transitory nature of their adult life and/or the absence of suitable breeding places on board ship, can survive air journeys of similar distance. The siting of airfields in predominantly agricultural areas increases the variety of insects which may so be transported to new habitats. The numbers and variety of insects collected from aircraft in various parts of the world bear witness to the serious potentialities of the problem. Reliance for protection against airborne insect introduction has so far been placed to a large extent in the insecticidal treatment of aircraft, which as practised often falls far short of the ideal. Even where constant and long-continued vigilance has been maintained, as, for example, in Hawaii, numerous insects of agricultural significance have escaped the effects of insecticidal treatment and have succeeded in establishing themselves in new habitats.

There is no doubt that the general acceptance and enforcement of a combination of pre-flight insecticidal spraying and regular treatment with residual insecticides would reduce considerably the dangers of insect introductions resulting from air transport, particularly if the chances of failure of the human element involved were reduced by resorting to fully automatic spraying equipment. There would still be a risk of insects, more particularly those of agricultural significance, travelling secreted in places where spray could not reach them, even on the exterior of fuselages[20]. It is considered that greater attention should be paid to the preventive aspects of the problem, to airport insect control, and agricultural quarantines, than has hitherto been the case.

Although a high level of control is often maintained over one or more particularly dangerous local type of mosquito at international airports, other mosquitoes, and many insects of other kinds of actual, or potential, pest significance, are often allowed to breed unchecked. In 1949, for example, three species of mosquitoes were found to be breeding adundantly in ponded drainage channels bordering the runways at Nandi (Fiji), although the dangerous *Aëdes aegypti* was well controlled at that airport. During 1950, living examples of all three of the species concerned were collected from aircraft following their arrival at Whenuapai Airport

(New Zealand) from Nandi[20]. The fact that so many insects have been found in aircraft all over the world indicates that the general level of insect control at international airports is not of a very high order.

Economic entomologists know only too well that no safe generalisations can be made about the degree of probability as to whether species of insects, even those harmless in some localities, will become pests if introduced into other habitats. The only safe approach to the problem is to take every possible step to prevent accidental introductions. Comprehensive and efficient insect control at airports, by greatly diminishing the chances of insects entering aircraft at all, would increase materially the effectiveness of the insecticidal measures taken on board aircraft. At the same time, it would greatly reduce the chances of insects entering wheel cavities, or of depositing their eggs on fuselage exteriors[36, 37, 38]. Although complete insect control over even so small an area as that of an airport would be scarcely possible to achieve, it is considered that a sufficient degree of control could be attained by rigidly enforcing anti-mosquito measures, by permitting the cultivation of plants of any kind only under entomological surveillance, and by attending to the eradication of all kinds of domestic insects in airport buildings. These measures, supplemented by the regular spraying of insecticides from the air by a specially fitted aircraft maintained at the airport for that purpose, would result in such a lowering of local insect populations as to reduce the chances almost to vanishing point of locally bred insects entering aircraft. Aircraft insecticidal spraying and residual treatment would still have to continue, for many insects would still fly into airports from outside the controlled area, and a percentage of these would inevitably find their way into aircraft. The danger of insects being carried by air in plant material could be countered to a great extent by more rigid quarantine regulations prohibiting the carriage of any such material not subjected to fumigation before being taken into aircraft.

It is obvious that with the increasing development of air transport, the risks of accidental insect introductions will continue to grow. Past experience having shown that remedial measures alone offer incomplete protection against such introductions, it is contended that the future approach to the problem should be primarily a preventive one, insect control measures within aircraft no longer being regarded as the first line of defence, but instead being relegated to the position of a necessary supplement to cargo quarantine and airport insect control. The protection afforded by such an approach would be all the more substantial in that more efficient airport insect control, supervised by the agricultural and health authorities of the various States concerned, would serve the dual purpose of giving a high degree of protection against the export of local insects and the establishment of any foreign ones which might still evade the insecticidal measures taken in aircraft.

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REVIEWS

The following books are reviewed:—

Aircraft Jet Power Plants

Some Aspects of Fluid Flow

Advanced Fluid Dynamics and Fluid Machinery

Basic Wing and Airfoil Theory

Grenzschicht–Theorie (Boundary Layer Theory)

Applied Mechanics for Engineers

Teach Yourself Management

AIRCRAFT JET POWER PLANTS. Franklin P. Durham. Prentice-Hall Inc. New York. 1951. 326 pp. Illustrated. Index. $6.65 net.

The author of this book is Assistant Professor in aeronautical engineering at the University of Colorado, and he writes primarily for the benefit of students engaged on courses in aircraft jet propulsion. Assuming a knowledge of elementary thermodynamics and fluid mechanics and an acquaintance with basic aerodynamics, the author presents in a workmanlike manner the basic theory of jet propulsion power plants and of their principal components.

The gas turbine in its jet and propeller-driven forms, naturally, is the engine which attracts the greatest discussion, but the author's introduction to his subject, by way of an exposition of the principles of thrust and energy in a moving gas stream, embraces also ram-jet and rocket forms of power plant. In consequence, the two final chapters of the book which deal with ram-jets and rockets do not appear in any way divorced from the main discussion, as might easily have been the case.

The book has an essentially theoretical bias; the author is not concerned with engineering problems associated with the types of power plants which he describes. However, an ample number of diagrams and photographs is included to give the student an impression of the typical form of the various engines discussed. The style in which the theory is presented is refreshingly direct and the arguments are easy to follow. What might be termed the fundamental theory is introduced as necessary to enable the "applied" theory of component design and performance to be more readily understood. Chapters are devoted to discussion of turbo-jet engine processes, in which the influence of the component efficiencies on the overall engine performance is outlined, and to turbo-jet engine performance, when the important non-dimensional parameters which simplify the presentation of an engine's characteristic behaviour, are introduced. The turbo-propeller engine is then dealt with in a similar manner and chapters follow on the behaviour and design of inlet diffusers, compressors, combustion chambers, nozzles and turbines. The only major omission in this otherwise admirable presentation of the basic theory of the gas turbine, appears to be a discussion of the manner in which all these components must be matched together in a particular engine and of the way in which this matching influences the behaviour of the engine when it operates at conditions other than those for which it is designed.

With this small qualification the book can be recommended as an excellent text book for the student, which many others will also find of interest. Its value to the student is enhanced by the numerical examples and list of problems for solution which accompany each chapter.

SOME ASPECTS OF FLUID FLOW. Papers presented at a conference organised by the Institute of Physics in October 1950. Edward Arnold & Company. London. 1951. 292 pp. Illustrated. Index. 50s. net.

This book consists of a series of papers presented at a conference organised by the Institute of Physics in October 1950. The papers deal with problems of fluid flow which arise in industries such as steel, coal, gas and glass, and which are often more complex and difficult to study than problems in aeronautics. Thus, in a steel furnace, for example, the high temperatures make measurements difficult as well as introducing buoyancy effects. The organisation of the conference and the speedy publication of the papers has been valuable in enabling those concerned with these problems to obtain surveys of what progress is being made. Because of the wide range of the papers it seems desirable to give a list of the titles. These are as follows:—

1. *Survey of Industrial Problems Involving Turbulent Mixing of Fluids* by M. P. Newby and M. W. Thring.
2. *Survey of Industrial Problems Involving the Combined Flow of Fluids and Solids* by Mr. R. L. Brown.
3. *Survey of Industrial Problems Involving the Pattern of Fluid Flow* by W. A. Simmonds.
4. *Survey of Industrial Problems Involving the Hydromechanics of Fluid Flow* by L. E. Prosser and R. C. Worster.
5. *Problems in the Atomisation of Liquids* by H. L. Green.
6. *Boundary Layers and Skin Friction in a Compressible Fluid Flowing at High Speeds* by Prof. A. D. Young.
7. *The Effect of Concentration on the Settling of Suspensions and Flow through Porous Media* by P. G. W. Hawkesley.
8. *Fluid Flow Through Beds of Granular Materials* by Dr. H. E. Rose.
9. *Some Aspects of Fluid Flow in Orifices, Nozzles and Venturi Tubes* by H. E. Dall.
10. *Techniques for the Study of Fluid Flow* by Dr. J. H. Chester, I. M. O. Halliday and R. S. Howes.
11. *Fluid Flow in Relation to the Manufacture of Steel* by M. P. Newby.
12. *A New Aerodynamic Technique Employing Radon for Tracing Gas Flow in Hot Systems* by R. Mayorcas and K. P. Perry.
13. *Theory and Design of Simple Ejectors* by R. A. Smith.
14. *The Laws of Motion of Particles in Fluids and their Application to the Resistance of Beds of Solids to the Passage of Fluid* by R. A. Mott.
15. *Turbulence Excitation on Ship Models* by Dr. J. F. C. Conn.

Turbulent mixing is one of the matters of most concern. It is important for combustion, ventilation and heat exchange but, although the theory of turbulence is advancing, it will be long before the basic theory will be of great help in these industrial fields.

The use of models and of dimensional analysis (really two aspects of the same approach since a model implies a dimensional analysis) are becoming common, although it seems that there are some opponents to models. This opposition must come from the more practical engineers as the value of model testing in general is now rarely questioned. It may be impossible, for example, to make a model of a coal mine which is suitable for the study of its ventilation problems, but an objection to models in general cannot be sustained.

The difficulties of measurements in furnaces and in mixtures of solids and fluids are serious and the importance of new instruments and techniques is stressed. The use of radon, a radio-active gas, in the study of fluid flow, is described in one of the papers and with further development this method may become practical. Such work as this may have an application in aeronautics in the study of flow in gas turbines and in low density wind tunnels.

While there is much for the aeronautical engineer to learn from these papers, some of the knowledge of fluid flow which exists in the aeronautical world has not yet been fully appreciated in other fields. It is partly for this reason that one is a little surprised to find included in the volume a paper on boundary layers at high speeds by Professor A. D. Young, of the College of Aeronautics.

ADVANCED FLUID DYNAMICS AND FLUID MACHINERY. R. C. Binder. Prentice-Hall Inc. New York. 1951. 426 pp. Illustrated.

Dr. Binder's book opens with the admirable definition: "Fluid mechanics is that study of fluid motion involving a rational method of approach based on general physical laws and consistent with the results of modern experimental study." There follows quite the best elementary introduction to the subject that the reviewer has seen. As the definition implies, fluid mechanics is here treated as a subject in its own right, not as a mere appendage to mathematics or to engineering, fields of which the reader is not presumed to have any special knowledge.

Most of the readers of the book will probably be either (*i*) students of fluid mechanics with a mathematical background, who will find most useful the descriptions of different machines involving fluid motion and the mechanical principles governing their performance, or (*ii*) engineers, who will painlessly learn from it the mathematical devices for making a quantitative analysis of fluid motion. There is about an equal quantity of material in the book meeting the needs of each of these two classes.

As is essential in an introduction to fluid mechanics the bulk of the theory is one-dimensional; this includes, however, a thorough analysis of the effect of friction and heat transfer, and the unsteady theory is developed far enough to make possible analysis of water hammer and surging. In addition there is a descriptive chapter on boundary layers and turbulence and four chapters developing the mathematical technique for two- and three-dimensional theory.

The pithy style of the book and excellent diagrams make it particularly easy reading. A student completely unprepared in fluid mechanics could certainly read it and then go straight on to, say, Goldstein's "Modern Developments in Fluid Dynamics," a book written on the same general principles at a higher level.

BASIC WING AND AIRFOIL THEORY. Alan Pope. McGraw-Hill. New York. 1951. 312 pp. 42s. 6d.

Professor Pope's book forms a valuable addition to those that can be recommended to aeronautical students. Its level is that of undergraduate Aeronautical Engineering in Great Britain, and the method of exposition follows along much the same sound lines as have been laid down here. There is sufficient novelty to provide helpful alternatives to more usual angles of approach, and the restricted scope of study allows space for detailed explanations and examples. This scope is circumscribed not only by the mental equipment assumed and a natural inclination towards the American point of view, but more particularly by limitation to inviscid and incompressible flow, which prevents treatment of the basic theories of skin friction, high speed air flow and shock waves, and their effects on aerofoil design.

Following introductory chapers on vectors, the complex variable, Fourier series and the like, there are two chapters on the elements of incompressible potential flow. Then Joukowski and Karman-Trefftz aerofoils are dealt with in detail. Two subsequent chapters, covering 58 pp., are devoted to the theory of thin aerofoils and Theodorsen's treatment of thick aerofoils. The remainder of the book is concerned with the monoplane wing and includes an introduction to sweepback and a discussion of Multhropp's method.

As with all books on a growing subject, a reviewer finds it difficult to understand why this or that matter should be developed in detail to the exclusion of another approach, which in his experience seems to lead on more effectively.

Outstanding among instances in the present case is the omission of aerofoil phenomena and theories appropriate to high Mach numbers, and of the basic work necessary to enable them to be understood—an omission regarded as reactionary even at the undergraduate stage in this country. However, Aerodynamics is becoming recognised generally as a many-headed colossus urgently requiring subdivision, and America may be prepared to carry dismemberment farther than we are at present.

This book is well written and illustrated. The subject matter is presented in its correct historical setting and documented with suitable references. The reviewer must congratulate the author on his frontispiece.

GRENZSCHICHT–THEORIE. H. Schlichting. Verlag G. Braun. Karlsruhe. 483 pp. Illustrated. *In German.* £3 15s. 0d.

As Professor Schlichting points out in the preface, at the turn of this century the theoretical subject of hydrodynamics, which was almost exclusively concerned with the flow of a perfect fluid, and the highly empirical subject of hydraulics were pursuing divergent paths and were apparently irreconcilable. Professor Prandtl, with characteristic genius, supplied the missing link needed to connect the two subjects when in 1904 he presented for the first time the idea of the boundary layer. As a result the logical development of much of modern aerodynamics was made possible, and it is no understatement to say that there are few problems in aerodynamics today which can be approached rationally without a clear understanding of the physics of boundary layer flow.

Professor Schlichting's book is the first comprehensive text book on the subject of boundary layers since "Modern Developments in Fluid Dynamics," edited by Professor Goldstein, was issued in 1938. Readers of this latter book will be familiar with much of the book under review, but in addition Professor Schlichting deals in rather more detail with the aspects of the subject that have received a great deal of attention in various countries during the 1939-45 War and in post-war years, such as the stability of the laminar boundary layer, boundary layer control, boundary layers in compressible flow, the development of turbulence, the effects of roughness, boundary layers in three dimensions and the determination of profile drag.

Although the book's title can be translated as "Boundary Layer Theory," the physical and practical aspects of the subject are given their rightful weight and the author does not neglect any opportunity to use physical and intuitive arguments where they can help the reader. The presentation is logical without being unduly dry or academic, and each of the twenty-four chapters has a full bibliography, including very recent work. In addition there is a list of titles of text books and collected works at the end of the book for further reading. The layout, printing and diagrams leave no cause for complaint, and the reviewer was only able to note one unimportant misprint.

For aeronautical engineers who read German this book should prove valuable both as a text book and reference book. For the sake of those who do not read German it is to be hoped that the book will be translated into English soon enough for it not to be out of date when issued.

APPLIED MECHANICS FOR ENGINEERS. Sir Charles Inglis. Cambridge University Press. London. 1951. 404 pp. Illustrated. 42s.

For a book on statics and dynamics, and their application to engineering problems, this is as admirable as it is unusual, and treats a well-worn theme with a freshness of approach which is both effective and stimulating.

The subject matter of the book falls broadly into three parts: first, the statics of rigid bodies; second, particle dynamics and the dynamics of rigid bodies; and third, the application of the preceding to a wide variety of practical engineering problems, concluding, appropriately, with a first class chapter on gyroscopes. To keep the length of the book within managable proportions, there is only a passing reference to fluid mechanics.

Although the book is not an introduction to the subject, in that the author assumes some preliminary knowledge of the fundamental principles of statics and dynamics, and of the mathematical techniques of differentiation, integration, and solving simple differential equations, little more is assumed than would normally be learned by most engineering students during their first year at a university. The result is that the subject matter of the book is eminently suited for engineering students in their second or third year. But in books for students, *how* matter is presented is as important as *what* is presented, and in this respect too, "Applied Mechanics for Engineers" is excellent. The author has obviously taken great care to make the book readable and easy to follow, and the result demonstrates the author's intimate knowledge of student needs.

The author's emphasis on mathematics as a tool and not an end in itself is obviously right in a book for engineers, as also is his practice of "employing the simplest mathematical methods in preference to those which may be more elegant but less obvious." The omission of all reference to Lagrange's equations is more questionable. The method is such a powerful one for many types of vibration problem that not to give even an elementary treatment seems a pity. On the other hand the attention given to step-by-step methods of solving the non-linear differential equations which are now occurring in so many branches of engineering is most encouraging. A bad examination subject this may well be, but its value to future engineers is beyond question.

The very few references to comparable or more advanced work is a little surprising, and it is a pity that there is no bibliography to guide students with regard to more advanced work on the subject.

The format, printing, and diagrams are all of a high standard, and the production of a work of this kind, extending to over 400 pages, for two guineas is, today, something of an achievement.

TEACH YOURSELF MANAGEMENT. M. Gilbert Frost. English Universities Press. 197 pp. 8vo. 6s.

The author opens the Foreword by stating that "there's no magic in Management." One may agree wholeheartedly with this sentiment and also believe that there is no magic in mathematics, chemistry, economics and physics. Would one, then, seriously believe that any one of these subjects could be learned from a slim volume, less than two hundred pages, by oneself? Is it any more likely that Management would be learned all this much easier?

It is necessary to say that much before considering the book in any detail. The degree to which it must be superficial is obvious and the sole remaining questions for a reviewer are, is it useful in spite of the dilution, and are there any outstanding defects or advantages?

Regarded inside this framework, it is a well-prepared and carefully condensed account of the main functions of modern management, but it contains no new features or theories, which do not already find their place in standard works of management literature.

For those who have made any formal study of management this book is useless. For those who are students of other matters, an account of this type is excellent and the book could be recommended to career advisors, school teachers and others concerned in the guidance of young men as to their future work.

In particular young engineers could well read it during their course so that they might see the field in which the manager operates, compared with that of the technician or the engineer.

Since it is highly improbable that managers will read the book at all, any efforts made therein to improve existing managerial practices will have been wasted. In future editions the author would be wise to recognise this fact and to devote the space so saved to a few more examples of management practice similar to those already included which are useful to the untrained reader in understanding the text.

CORRESPONDENCE

ANGLO-AMERICAN UNITY

Looking back in retrospect on recent aeronautical activities in this country, it may well be that time will show that we have just passed another of those milestones in British Aviation History. There are a goodly number of these spread over the past 40 years, and our President referred to a few of the most outstanding of them during one of his Brighton speeches.

Whereas we have every reason to be satisfied with the solid technical achievement of the Anglo-American Conference at Brighton and are devoutly thankful for having had the opportunity to see demonstrated at the S.B.A.C. Farnborough Exhibition the new family of British Military aircraft which it is believed will become classic, and will be proved to be unsurpassed the world over, nevertheless we must not for one moment fail to recognise the profound importance of the many opportunities which were afforded to re-affirm our friendship and unity with America, the true spirit of which was so ably summed up at the closing ceremony at Brighton by the remarkable speech of Lord Brabazon of Tara.

It is considered that this speech was one of the most moving and important addresses ever made on this vital matter and will go down to history.

I hope that every member of the Society, both at home and abroad, will read it and ponder it, and show it to his colleagues and friends.

Let it be our gospel for the future, for without a shadow of doubt it is the one thing above all others we should work for and foster, so as to ensure a close partnership between the British Commonwealth and the United States.

ROY FEDDEN, *Fellow*

HYDRAULIC UNSERVICEABILITY

In the paper by Messrs. Bound and Conway (JOURNAL, July 1951), the main causes of hydraulic unserviceability in well-established designs were shown to be:—

(1) Leaks, due to fractured pipes or faulty connections.

(2) Dirt.

As hydraulic systems are already a well-established and accepted means of transmitting power it would appear that any feasible technique which might improve reliability would be worth trying, even if it were slightly unorthodox by present standards.

It is suggested that piping should be installed between components in continuous lengths, being " fed into " the aircraft structure during an early stage of manufacture, or shorter and more manageable lengths could be welded *in situ*. The difficulty of perfecting a welding technique should not deter the manufacturer. The benefits are two-fold. All inter-pipe couplings become eliminated, thereby removing the sources of scores of leaks in a modern installation and a saving in weight is achieved.

The larger the aircraft the greater the theoretical saving of weight and number of connections; this will be particularly apparent where the design includes long uninterrupted runs of piping. Piping to elevator and rudder power flying controls, tail wheel and deck hook operating jacks would appear to be worthwhile applications.

Until even the most simple hydraulic components give trouble-free operation for at least 1,000 hours, it is not recommended that pipes should be welded or permanently fixed to them.

It is suggested that centrifugers, gear-driven by the hydraulic pumps, would assist in the elimination of dirt and swarf already within the hydraulic system. Centrifugers are capable of handling large outputs, but the writer does not know whether they are capable of separating micronic particles. The introduction of foreign matter to the system might possibly be reduced by fitting sleeves to all jacks, especially those in exposed positions such as in wheel wells. Presumably the practice of fitting rubber concertina sleeves was discontinued due to the inability of rubber to withstand the wide variations of temperature; synthetic materials are now available to designers.

In spite of the additional weight of refinements that may be added to hydraulic systems, it is possible that some of the emergency circuits may become eliminated because of the increased reliability of the main system.

P. M. W. NOEL, *Associate Fellow*, Australia

MR. CONWAY'S REPLY

The suggestion about the use of long lengths of welded pipe is certainly of interest; it has been considered by us on past occasions and some welded Tee joints were seen on German aircraft during the Second World War. There are, however, practical welding difficulties to be overcome if reliable pressure tight welds are to be made on thin piping, without excessive " build-up " on the pipe bore at the joint. Portable X-ray equipment has had to be used on large diameter oil pipe lines which are welded *in situ*, and we wonder if aircraft standards of inspection would involve such procedures.

There are many joints in normal pipe runs which are conveniently situated to enable the aircraft to be broken down into sections for manufacture or repair, and these must be retained. Furthermore, there are many more bent pipes than straight ones on the average aircraft and the number of pipe joints which could, in fact, be welded are sufficiently few to discourage the development of the necessary welding technique.

However, we agree with Mr. Noel that the use of longer pipe lengths and the elimination of pipe joints is something to be encouraged.

As regards centrifugal cleaning of oil, we do not believe that very fine particles would be separated and anticipate frothing troubles with the centrifuge. "Micronic" filters are, in our opinion, better.

Rubber bellows on hydraulic jacks are not liked because they must be able to breathe and tend to collect dirt inside which can only be removed by dismantling the bellows. In practice, jack piston rod seals are usually more reliable than the internal piston seals.

H. G. CONWAY, *Fellow*

MR. BOUND'S REPLY

I agree with Mr. Conway's comments but would like to add the following.

Even when the most complicated hydraulic components give trouble-free operation for 1,000 hours, it would still not be advisable for pipes to be welded permanently to them, as there must always be a stage of reconditioning or modification, and therefore it is essential to utilise a connection which can be separated from the component without the use of a hacksaw.

Mr. Noel states that the practice of welding pipes *in situ* would eliminate intra pipe couplings, thereby removing the source of " scores of leaks " in a modern installation. I cannot believe that there are " scores of leaks " on modern hydraulic installations.

R. H. BOUND, *Fellow*

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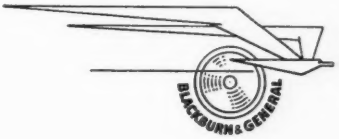

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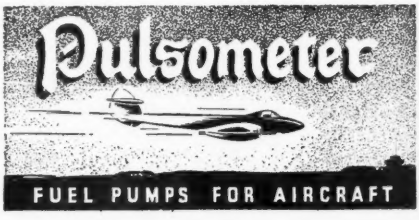

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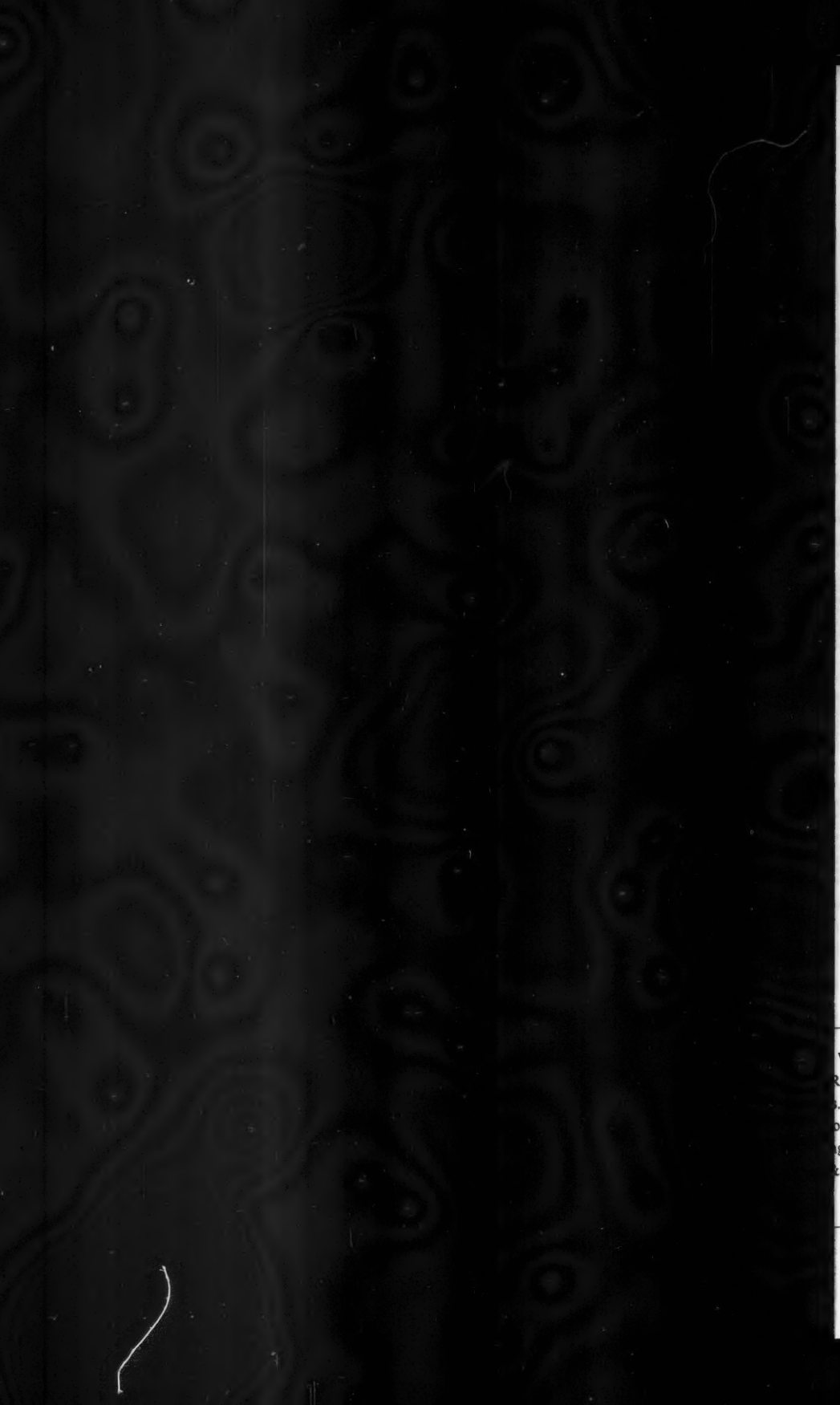

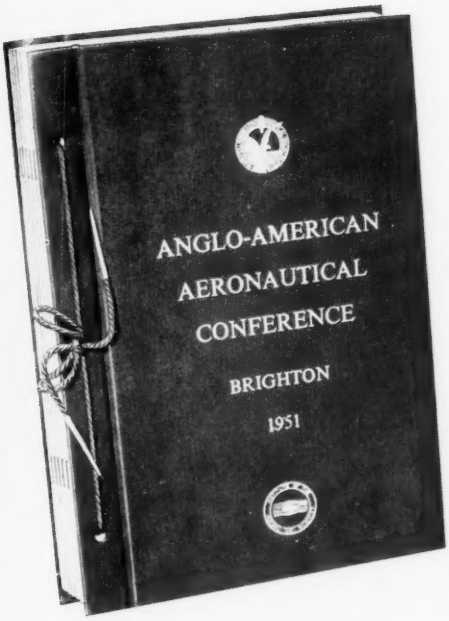

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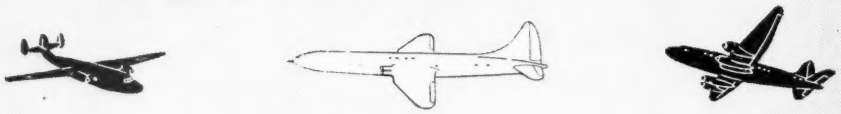

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